The Dock & Harbour Authority

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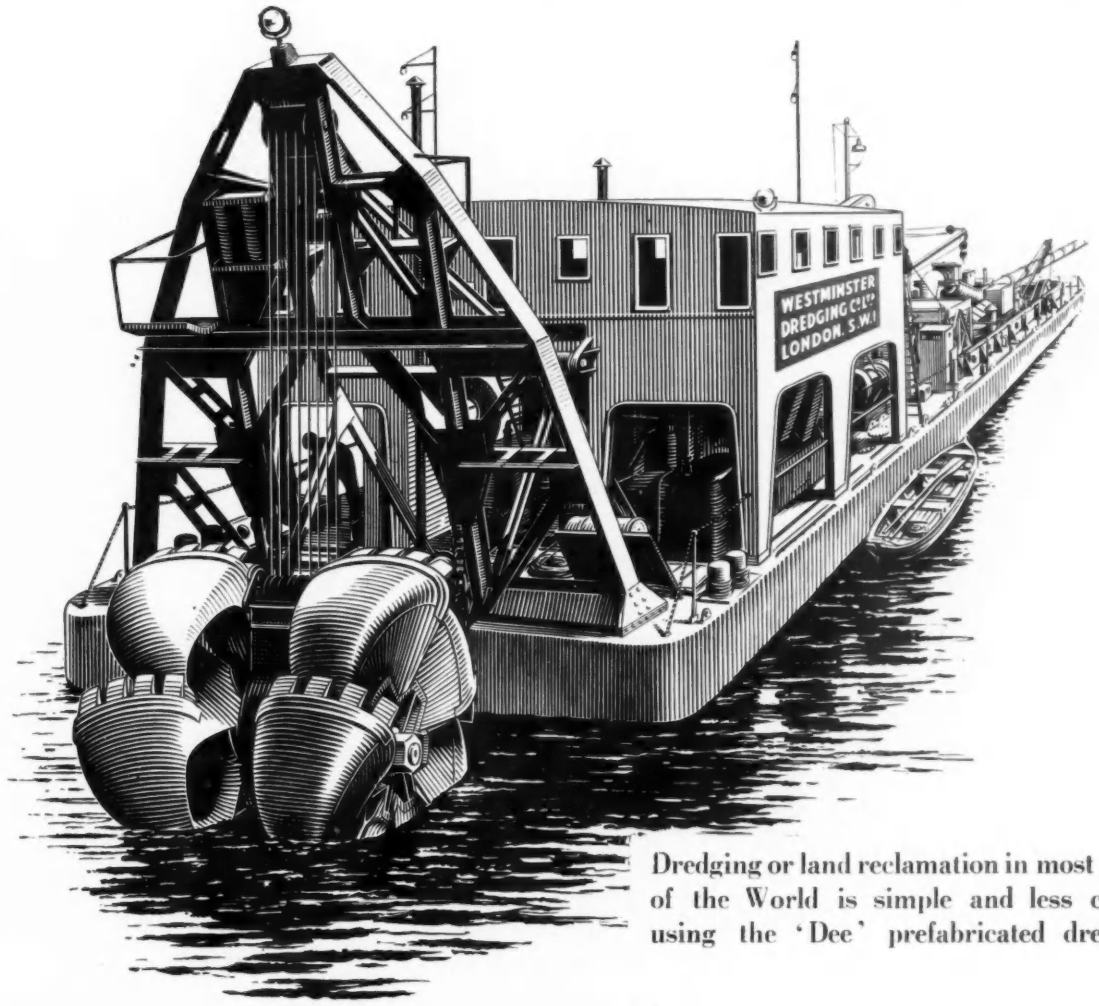

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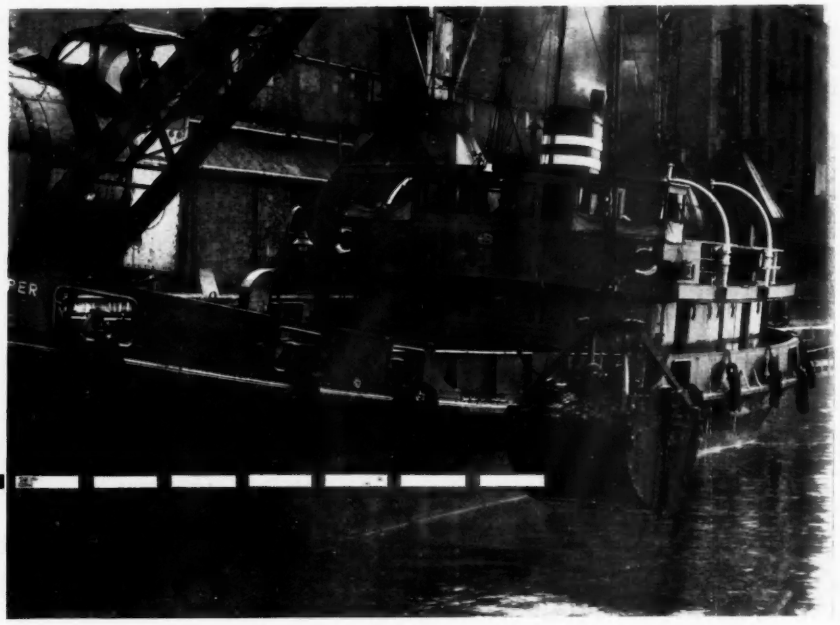

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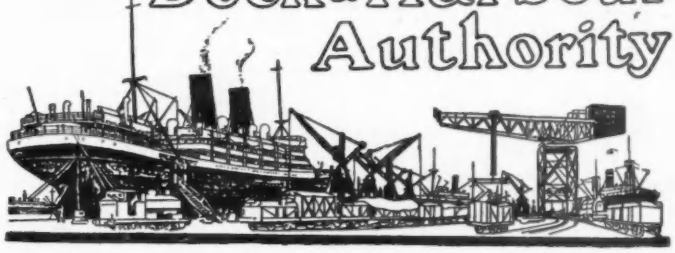

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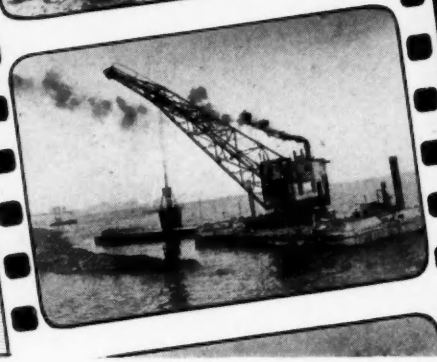

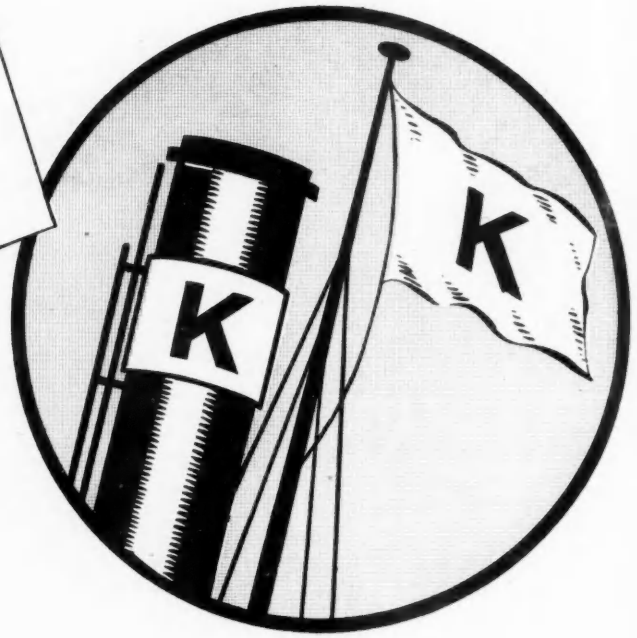

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Editorial Comments

THE PORT OF OAKLAND.

The Port of Oakland is situated on the eastern shore of San Francisco Bay, California, and is connected with San Francisco (five miles distant) by the San Francisco-Oakland Bay bridge, 8.4 miles long, and facing the famous Golden Gate. It has a municipal airport, and is a port of call for 50 steamship lines, and the western terminus of the Santa Fe, Southern Pacific, and Western Pacific Railways. It is the third city of the State in size, with a population of over 300,000.

The Port has 27 miles of waterfront, 85 large docks, wharves and piers, and the trade is over 4,000,000 tons per annum.

The history and development of the City and Port makes interesting reading. It was one of those towns brought into existence by the Californian "gold rush," at which period of its existence its only claim to shipping activity was a ferry service to San Francisco, which then formed its sole trading facility.

An outstanding feature of the port is the fact that it has been created, almost entirely by reclamation of tidal lands and shallow waters, with soil dredged from the estuary channels. This work was carried out by the Government of the United States who early recognised the importance of Oakland as a potential deep water port. The primary reason for so quickly turning to reclamation schemes seems to have been due, in the first place, to the real estate exploits of an individual, whose shrewdness one cannot but admire, however much one may deplore the circumstances which enabled a man's property rights to override, for half a century, the collective interests of all the other inhabitants of the town. Eventually, the vesting of the ownership of all lands below low water mark in the town of Oakland marked the beginning of harbour development.

With large expanses of water available, in some cases of considerable depth, present and future developments favour the "finger" pier principle, so popular in these circumstances in North American and Australian ports, although in Oakland, some considerable stretches of straight or marginal quays are also in existence in suitable situations, and more are planned for the future.

It will be seen from the article which will be found on a following page, that the transit shed and quay layout of the straight quays, except for the lack of quay cranes and the rather narrow quays, follows normal British practice. Future piers, however, are to be from 500-ft. to 800-ft in width, which should give more adequate quay space, to allow for the railways and roads, and shed accommodation, which must be provided to meet modern requirements.

It is noteworthy that the recent war construction works of the U.S. Army, Navy and Air Force have played a significant part in the development of the Port, and besides the Almeda Naval Air Station, there is a Municipal Air Port at which there is a progressive increase in air transportation of many types of commodities.

With so favourable a situation, and unique facilities unhampered by physical restrictions, there is no doubt that the port of the future will be one comprising the most modern planning and layout.

THE ST. LAWRENCE SEAWAY.

In this issue will be found the second instalment of the article on Winter Navigation on the St. Lawrence, followed, on page 252, by pronouncements on the St. Lawrence Seaway and Power Project. Our readers will note with interest the strong lines taken by both the President of the United States and the Minister of Transport of Canada, in their recent statements which we now publish.

The President's message shews no departure from the attitude taken by him in the Senate in 1941, and on many occasions since. Indeed, in both the President's and the Canadian Minister's words there seems to be a hardening of insistence of the need for the combined development of navigation and power, and although we have no further information that any other official action has been taken by either Government, many utterances by influential people have been made in the Canadian Press, putting the case for the Seaway and its power potentialities in the strongest possible light.

In the United States also, the matter is receiving increasing attention; the steel industries now appear to be becoming more favourable to the scheme, because of the need for importing iron ore from the extensive deposits now being developed in Labrador, with the aid of American capital which has been invested in that region. In addition, increasing interest is being evinced by the farming States of the West, and the rich agricultural and industrial regions of the Great Lakes and the North East, and by Federations of Labour.

It has many times been claimed that, from the geographical point of view, the St. Lawrence Seaway Project is an inevitable development, and in some cases, even opponents of the project are now admitting that this may be so, for it appears that the Mississippi Valley waterway interests have been advised to make their long term future plans and activities on that assumption.

There are some, when contemplating the enormous supplies of fresh water running needlessly to waste, who say that it is a matter for wonder that opposition to the project has, for many years, successfully prevented advantage being taken of the tremendous power resources and potentialities that are available. Protagonists of the scheme point out that probably 90% of the seaway already

Editorial Comments—continued

exists, and that the population of the States and Provinces bordering the St. Lawrence and the Great Lakes, is in excess of sixty million people engaged in industrial and agricultural pursuits and in shipping and shipbuilding.

Matters have now reached a very interesting stage and if the project eventually receives the assent of Congress, we hope it will be pressed forward with drive and efficiency, and that the question of depths of channels and locks, and the problem of overcoming the great handicap of ice, will be satisfactorily resolved.

TABLE BAY HARBOUR.

The great number of ports all over the world which are planning for immediate and future development is, to some extent, a result of the war, as in the majority of cases, port improvement works during the war years were impracticable. There were a few instances, however, where ports remote from the areas of actual hostilities, were enlarged or had their handling facilities improved to enable them to deal with abnormal conditions of increased traffic.

In peacetime, however, when working conditions are normal, port improvement activities are usually a sign of vitality on the part of the port administrations concerned, who are quick to appreciate the fact that trade and traffic is, to a great extent, the result of adequate transport facilities and not *vice versa*.

One of the latest notices about port improvement we have received concerns Table Bay Harbour, Cape Town, which is administered by the South African Railways and Harbours. Recently, the Cape Town Chamber of Commerce approved the recommendations of a Departmental Committee for the further development of the Port. We understand that this memorandum has now been submitted to the General Manager of the South African Railways and to the Minister of Transport.

The schemes put forward suggest no extensive development, but rather the plan is to concentrate upon the improvement of existing facilities. For example, particular emphasis is given to the urgent need for increasing the number of cranes, as well as for the provision of a heavy lift floating crane and other mechanical handling plant, for general and bulk cargoes and timber. Attention is also drawn to the inadequacy of present shed accommodation and the desirability of developing the existing quays and berths in the Duncan Dock. The memorandum emphasises that additional shed accommodation would facilitate and extend the transhipment trade of the port.

The need for an adequate passenger marine terminal has also been stressed in view of the increasing importance of the tourist industry, which is becoming a valuable asset to the Union of South Africa.

WATER POLLUTION RESEARCH.

The Report of the Water Pollution Research Board, describing the work of their Laboratory for the year 1949, has recently been published. It reviews briefly the year's events in the field of water pollution prevention in respect to water supplies, and, *inter alia*, to sewage treatment and purification, treatment of effluents discharged by paper mills, the toxicity of substances to fish, and the polluting effect of sewage and industrial waters.

Under the latter head, a short interim report is given on the preliminary work on the Survey of the Thames Estuary. As we have already stated in previous issues, this survey is being made, in conjunction with a tidal model, on behalf of the Port of London Authority, in order to examine the causes of siltation and allied matters. The present report describes the work so far carried out, which has consisted mainly in studying the condition of the estuary waters, *i.e.* examination of samples of the bottom deposits, concentration of solid matter in suspension, salinity, temperatures and oxygen content.

It is interesting to observe that in the central reaches of the Thames, the cencentration of dissolved oxygen was very low, and that the bottom deposits in those areas at times evolve gases including methane and hydrogen sulphide as a result of anaerobic fermentation. This may have been the source of the minor trouble experienced by vessels in respect to their white paint work, upon which we commented in our November issue of last year.

The work if the Water Pollution Research Laboratory of the Department of Scientific and Industrial Research cannot be too widely publicised, as their investigations are particularly important now that legislation is imminent in respect to the strengthening of the existing law relating to pollution of rivers and enforcement of purification standards.

Any advice or information which can be given by the Laboratory is at the disposal of all those concerned with problems of water pollution. The Report is obtainable from His Majesty's Stationery Office, price 1s. 6d. or 1s. 8d. by post (40 cents U.S.A.).

UNSATISFACTORY CONDITIONS AT SOUTH AMERICAN PORTS.

Frequently, reports are published in the Press concerning the unsatisfactory state of affairs at many South American ports. Shipping congestion is a frequent complaint, as also is the absence of adequate cargo handling facilities, and the discontent and unrest among dock workers owing to their low wages and poor working conditions.

A typical example of adverse criticism is to be found in the annual report of the British Chamber of Commerce in Uruguay, which gives details of the Port of Montevideo. This says that the volume of oversea shipping using the port during the year ended June, 1950, averaged about 36 vessels per week in 1949 and 40 per week in 1950. Shipping arrivals have been spasmodic, with a few periods of relative slackness, but frequently there were times when the port has been so congested that vessels have had to lie at anchor awaiting a berth at the quays.

During these periods of congestion, the facilities of the port proved inadequate; besides a shortage of labour, there are insufficient railway wagons, cranes, shore winches and other cargo handling facilities, to enable ships to work to capacity, and many vessels have experienced serious delays in consequence. Much of the existing equipment is in need of repair, and new equipment is also urgently needed for loading and discharging vessels.

Labour demands for increased wages have been much in evidence during the past year, and to alleviate the position various increases of wages have been imposed by legal decree. Also in a further endeavour to effect an improvement, the Port Labour Unions have recently formed a Co-ordinating Committee to arrange joint action when disputes arise.

Unfortunately statements similar to the above, are all to frequently made about other South American ports, and as far as their social and working conditions are concerned, there is little doubt that South American dockers lag far behind the majority of their confreres in Europe.

PRAISE FOR BRITISH DOCK DECASUALIZATION SCHEME.

In view of the foregoing, it is encouraging to learn that an improvement in the morale of dock workers is to be seen at many ports in the United Kingdom. This is claimed to be one of the results of the dock decasualization scheme which has been in operation since 1941, and foreign visitors especially have remarked upon the advantages the British dockers obtain from the scheme.

Giving some reasons for the improvement, the chairman of the Liverpool group of the National Dock Labour Board, writing in a recent issue of the group's bulletin, states that there is evidence to show that the bulk of registered dock workers on Merseyside are now happier and more contented than they have ever been in the history of the industry. The fact that a regular wage is now coming in each week has caused a revolution in thousands of Merseyside homes, and the applications from hundreds of men in other occupations, who would like to join the scheme, prove how desirable a job at the docks is now considered to be.

The recent education conference for dockers has also proved a successful experiment, and the Board hopes that these activities will become a normal part of the social and industrial life of the docker.

When one considers the progress which is being made with the scheme in the United Kingdom, it would seem that other countries might well adopt a similar plan. The first essential, surely, is to overcome the evils of casual labour, and until this is done, and a permanent job is assured, so that the dock worker can acquire a measure of self respect, it would seem that there is little hope of finding a satisfactory solution to this serious social problem.

The Port of Oakland

Progressive Seaport of California

By J. WALTER FRATES and GWEN EVANS.

OAKLAND HARBOUR, strategically situated on the mainland shore of San Francisco Bay, one of the largest and most modern sea ports of the United States, is constantly improving and expanding to keep abreast of the bay area, fastest growing region of the Pacific Coast. As can be seen by the accompanying photograph, Oakland Harbour comprises the waterfronts of the cities of Oakland and Alameda. The City of Oakland portion of the harbour comprises some nineteen miles of waterfront, two-thirds of which is owned by the municipality, and which extends from the Oakland approach to the famous San Francisco-Oakland Bay bridge, through the Outer and Middle Harbours, up the nine mile long Oakland estuary to the Oakland Municipal Airport. Along this harbour are the facilities of the Port of Oakland, operated by the city under the Board of Port Commissioners, which also administrates the Airport, and many industries and terminals.

EARLY HISTORY OF THE PORT.

It is hard to believe that litte more than 100 years ago, this valuable waterfront, land and air terminus could be described as an evil-smelling strip of muddy tidelands with an occasional strip of sandy beach; on one side a flotsam-filled creek and on another a vast bay of salt water, while on the shore, there were a few scattered shacks and dusty rutted roads.

A picture of the waterfront of the early 1850's is a picture of the town itself in its cradle days. Oakland was a typical American small-port village, clustering mainly about lower Broadway, known then as Main Street.

During the years of the gold-rush, the thriving town of San Francisco, situated just across the bay, needed lumber, vegetables, dairy products, etc., and thus it was that Oakland became a port "exporting" these and other items by means of a ferry service. The waterfront was the heart of the village existence. Here was the centre of what business there was, the ferry, a lumber yard and planing mill, and sand for the plaster and mortar of the first brick buildings,

The Ferry service, if it could be called that, was at best irregular. The captain and wharfinger studied tide tables and decided when the ferry could land and depart. When these calculations were finished, a boy was sent running through the streets blowing a horn to announce the event.

It was in 1855 that the first step was taken toward the creation of a seaport. That year, the Oakland City Council, itself scarcely a year old, advertised for bids for the removal of a bar at the entrance to the Estuary, which then could be crossed only by boats of the shallowest draft. In 1859 an expenditure of $14,000 was made to dredge the bar and build rock-filled levees at the estuary entrance.

Since that date, with the aid of the United States Government, which early recognised the importance of Oakland as a potential deep water port. Approximately $9,000,000 has been spent to provide deep water channels to Oakland.

Historic struggles mark the early days of Oakland's harbour, long before the people of Oakland decided in earnest to have a port and created the Board of Port Commissioners and the Port of Oakland in 1927.

Strangely enough, this world port has been literally created from tidelands which before 1852 were below the low tide line. The natural waterfront, which essentially was the reason for building the town of Oakland, was given away to one of the early settlers, Horace W. Carpentier, who is alternately described as a man of great vision who saw the potentiality of the mainland across the bay from San Francisco, and was almost single-handedly responsible for its early development, and as a shrewd "Yankee lawyer" who saw many ways of cashing in on the California gold rush.

Probably there is truth in both descriptions, for certainly the development of the little village was advanced by Carpentier, and his fortune was made by that development. Soon after he had obtained from the trustees of the newly incorporated town the deed and rights to the waterfront, public opinion turned against him, and there ensued fifty years of legal strife, during which the people of Oakland attempted to regain the waterfront rights they had so carelessly lost. Development of the harbour continued, however, during this period.

The first federal recognition of Oakland's potentiality as a seaport was in March, 1873, when Congress directed a board of Army Engineers to investigate and report on plans for the development of the harbour. In 1874, after a favourable report, Congress appropriated funds for the construction of adequate jetties at the mouth of the estuary and the following year dredging of the estuary was undertaken. Stalemates in the legal battle which threatened the growth of the harbour were overcome by the Federal recognition of the importance of the harbour and Governmental refusal to allow private interest to tie up a navigable waterway.

In 1887, Oakland citizens proudly claimed that at high tide, vessels drawing 15-ft. of water could enter the harbour. Now 73 years later, the minimum water depth at the Port of Oakland facilities along this same estuary and in the Outer Harbour is 32-ft. at low tide. The material dredged to create and maintain ship channels since 1878 has been used in reclamation work and it is on this filled tideland that a great part of the Port exists.

While the township could not regain its natural water front, the courts decided in 1907 that all lands beyond the low tide mark of 1852, belong to the City of Oakland, and in 1911 the California State Legislature granted to the City full right and title to practically all of the water front tide lands. Thus the hold of private interest over the Oakland Harbour was broken and it has never been allowed to return.

Following these decisions, the people of Oakland became very actively interested in the harbour. Meetings were called, studies made, and in the November election of 1909 a bond issue of $2,503,000 for harbour development was passed.

During ensuing years, moneys from tax levies were spent for harbour improvement, the work being carried out by the City's Department of Public Works.

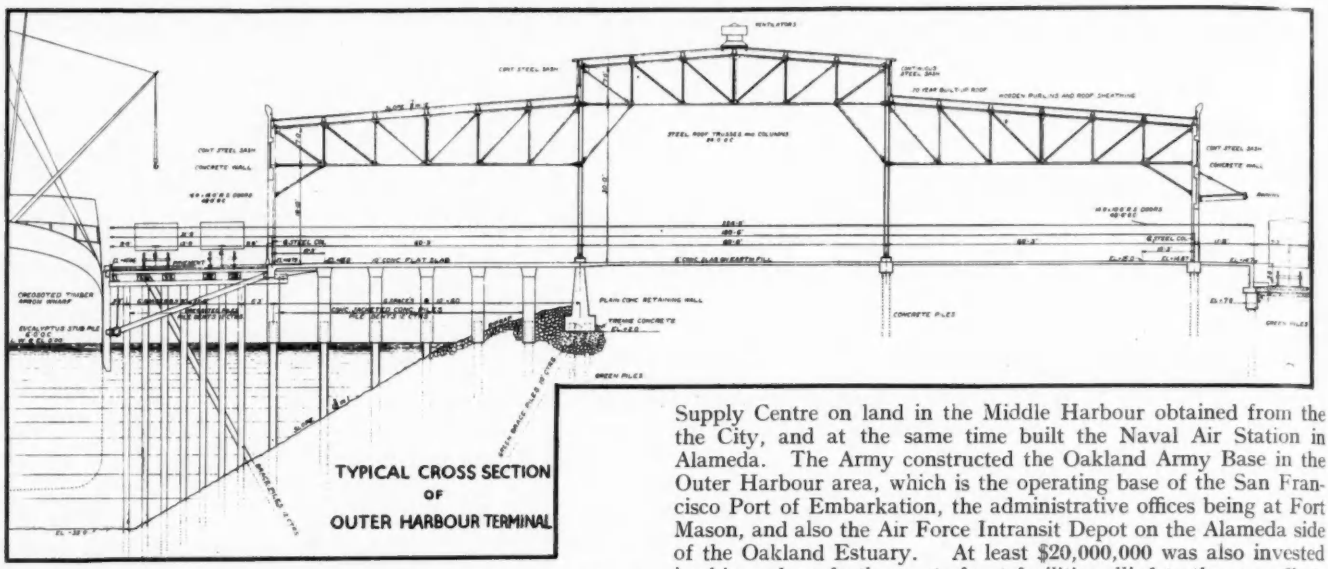
BOARD OF PORT COMMISSIONERS

Where once private interest had impeded the progress of the harbour, now, unfortunately, changing political administrations brought changes in port policy and the resulting lack of stability greatly hampered its growth. Investigations proved to the people of Oakland that the development and operation of a port is a business enterprise, which requires in turn a business management, and that the Port of Oakland should be administered by a specially created port authority, distinct from the city's governmental body.

Consequently in the election of 1925, the public gave its approval to the creation of a Board of Port Commissioners and voted a bond issue of $9,960,000 for harbour improvement and the provision of adequate facilities. Necessary charter amendments, however, delayed the creation of the first permanent Board until February, 1927.

The purpose of the Board is "to promote and more definitely insure the comprehensive and adequate development of the Port of Oakland through continuity of control, management and operation." It is a body whose five members serve without compensation, appointed by the Mayor of Oakland with the approval of the City Council. The terms of office of the Port Commissioners are for six years, and the present members are C. V. Goodwin, president; S. A. Burgraff and D. W. Frost, vice-presidents; and J. F. Galliano and H. W. Estep, commissioners.

The Port of Oakland—continued



The administrative staff of the Port of Oakland is headed at the present time by Arthur H. Abel, whose title is Port Manager and Chief Engineer and who also is the elected secretary of the Board. Mr. Abel is also the 1950 president of the American Association of Port Authorities, an organisation which encompasses the major ports of North, Central and South America.

PORT AND HARBOUR FACILITIES

Since the organisation of the Board of Port Commissioners, Oakland has spent approximately $15,000,000 in the improvement of the harbour and the construction of terminal facilities. Private interests also spent about $10,000,000 for similar purposes. The Board has improved the Oakland Municipal Airport, which, under the Master Plan for peace-time expansion, is an integral part of the harbour, and the United States Government also contributed, making a total expenditure of $11,000,000 for the Airport alone. During the same period, estimated expenditures of $20,000,000 have been made in Alameda. The total expenditure, therefore, for Oakland Harbour, regardless of other large sums spent for Governmental terminal facilities throughout the area served by the harbour, can be conservatively set at some $65,000,000.

Before and during the recent war, large expenditures were made by the armed services and private and public interests to make the Harbour one of the largest shipping and transportation centres on the Pacific Coast. The Navy constructed Oakland Naval Supply Centre on land in the Middle Harbour obtained from the the City, and at the same time built the Naval Air Station in Alameda. The Army constructed the Oakland Army Base in the Outer Harbour area, which is the operating base of the San Francisco Port of Embarkation, the administrative offices being at Fort Mason, and also the Air Force Intransit Depot on the Alameda side of the Oakland Estuary. At least $20,000,000 was also invested in shipyards and other waterfront facilities allied to the war effort, while other expenditures to increase the efficiency and service of the Harbour by both private and public interests were correspondingly large. A considerable portion of the war-time facilities are now devoted to industrial purposes.

Grove Street Terminal.

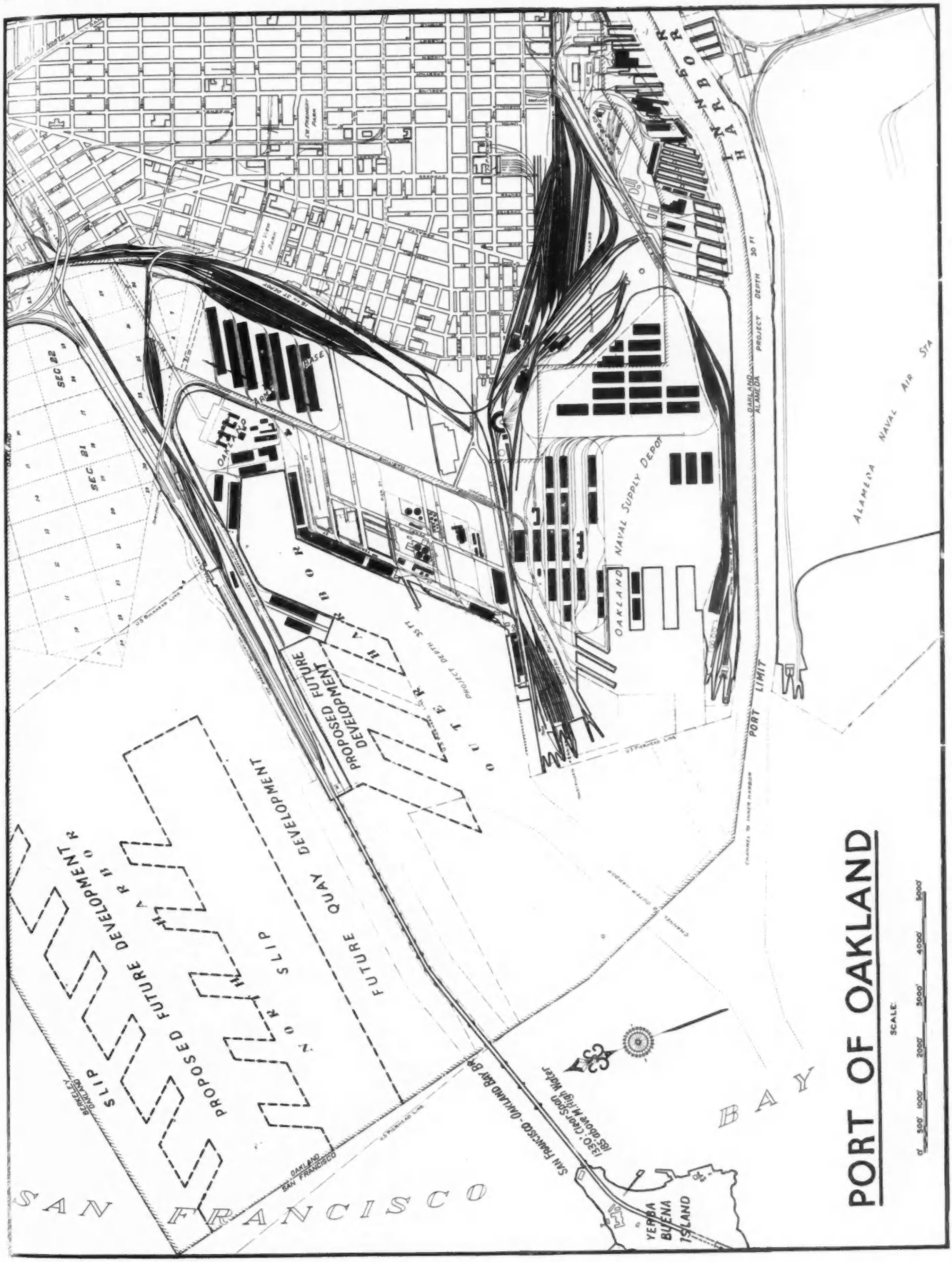
As a result of all this development, Oakland Harbour has grown in twenty-two years from a collection of poorly-planned, obsolete and dilapidated installations to the outstanding civil and military maritime base on the Pacific Coast, a valuable asset not only to the City of Oakland, but also to the people of California and the Nation, a peace-time centre of trade, and a vital source of supply in war.

The Army and the Navy war constructions added materially to the physical facilities of Oakland Harbour. In the Outer Harbour alone were added 5,820 lineal feet of piers and wharves, sufficient for the berthing of ten large ships, 2,500,000 sq. ft. of warehouses and transit shed space, and 37 miles of railroad tracks for car storage yards and service tracks to the piers and wharves. The Oakland Naval Supply Centre, which covers an area of more than 500 acres, incorporates fourteen berths for large vessels; 6,500,000 sq. ft. of storage space for warehouses and transit sheds, and about 36 miles of railroad trackage for yards and service needs. The Army's Intransit Depot on the Inner Harbour has berths for three large vessels; 700,000 sq. ft. of warehouse and transit shed space, and more than 5 miles of railroad trackage to serve the base.

The Inner Harbour, extending to the Airport, is an estuary 9 miles in length (approximately 5 miles of which is 800 to 1,000-ft. wide) along which the port and private interests have many valuable maritime facilities. Oakland Inner Harbour is bordered on the north by Oakland and on the south by Alameda, and provides a waterway along which large vessels can operate about as far as the Park Street Bridge. At the upper or eastern end is an artificial tidal canal connecting the estuary with a natural basin, known as San Leandro Bay, on the shore of which is located the Oakland Municipal Airport. During the past year approximately 200 acres of tidelands were reclaimed by the Board of Port Commissioners in the San Leandro Bay area for use as harbour industrial land.

Oakland Harbour, including both Oakland and Alameda, now has a total of nearly 13 miles of berthing space, sufficient for the berthing of about 60 large deep draft vessels; with 260 acres of covered storage and transit shed space of shipping terminals, and about 88 miles of railroad trackage at shipping terminals for car storage and operations. There are numerous small docks and wharves for the accommodation of barges and light draft vessels, and extensive shipbuilding and ship repair facilities.

The Oakland Municipal Airport property has a total area of 2,400 acres, which will be fully developed under the Board's Master Plan. A total of 1,700 acres will be utilised for airport operations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BAY

The Port of Oakland—continued

The Outer Harbour Terminal of the Port of Oakland faces the Golden Gate. At the far left is the Southern Pacific Railroad Company pier and a portion of the Oakland Naval Supply Centre. Next to the pier is the Seventh Street Unit, then the oil dock and the Fourteenth Street Unit. The Oakland Army Base is located on the basin to the left of the approach to the world-famous San Francisco-Oakland Bay Bridge.

and 700 acres are set aside as an airport industrial area. One thousand acres are, at the present time, used for airport operations.

DETAIL OF FUTURE PLANS

The Board of Port Commissioners is determined to make Oakland even more an asset to Northern California and the Nation, and has drawn up a comprehensive scheme which incorporates many important and valuable improvements, some of which have already been carried out since the scheme was adopted. The major features of this Master Plan, which governs all development of the port are:

1—The Port of Oakland has a total area of 1,540 acres in the North Harbour area, located north of and adjacent to the San Francisco-Oakland Bay Bridge and fronting on San Francisco Bay, on which it is planned to develop a terminal which will serve the augmented commerce and foreign trade of the future by ultimately providing berthing space for 90 large vessels. The first step in this development, which will be undertaken as needs demand, will consist of dredging, construction of a unit of piers, and related facilities.

2—The Outer Harbour will be enlarged by two large mole type piers, providing berths for 18 vessels. A new oil pier will be built replacing the existing oil pier, which will be removed and replaced by a general cargo wharf. The present Seventh Street unit of the Outer Harbour will be enlarged by the widening of the existing transit shed from 120 to 180-ft., and an additional transit shed 180-ft. x 720-ft. will be constructed.

3—Inner Harbour developments will be as follows: a combined pier and wharf, with a berthing length of 1,570-ft., providing berthing for three large vessels and a transit shed area of 219,200 sq. ft. will be constructed for the expansion of the Grove Street Terminal.

A wharf with a berthing length of 1,210-ft. and a wharf area of 100,000 sq. ft. will be built to serve a cargo storage area of more than 720,000 sq. ft. in the rear of the wharf.

Construction of a roadway to be called the Embarcadero is scheduled to begin this spring, with a width of 80-ft., which will provide access to the harbour and a connection with the new Eastshore Freeway, connecting the bay with the San Joaquin Valley. The section of the Freeway paralleling the harbour is already complete.

Four projects are planned for the expansion of the Ninth Avenue Terminal. They include a 600-ft. x 224-ft. easterly extension of the pier, a 370-ft. by 100-ft. extension; construction of a large warehouse 150-ft. x 350-ft. in the rear of the pier, and the building of a 1,500-ft. extension to the 180-ft. wide transit shed which has a length of 500-ft. To make these improvements possible the Board has recently acquired from the Richfield Oil Corporation a 5-acre tract of land fronting on Clinton Basin, which is now used for the handling of lumber shipments.

Provision has also been made for a 264-ft. x 2,296-ft. marginal quay type wharf complete with transit shed, trackage, and related facilities along Brooklyn Basin.

The Board has also acquired 675 acres of land at the head of San Leandro Bay, which is the easterly end of the Port of Oakland, and has drawn plans for a large shipping terminal with berthing for 28 large vessels and adequate transit sheds, warehouses, and industrial areas complete with supporting trackage, highways, and related terminal facilities. This large terminal, when completed, will serve the large industrial areas of East Oakland and San Leandro, which are being developed, and also care for the shipping

The Port of Oakland—continued

needs of the San Joaquin and Sacramento Valleys. To provide an adequate approach for large deep draught vessels the Master Plan contemplates the dredging of a new ship channel direction from San Francisco Bay into San Leandro Bay, and the use of the present tidal canal for lighter draught vessels.

In drawing up the Master Plan the Board of Port Commissioners has felt that Oakland has everything in its favour to provide a necessary, valuable, and unexcelled service to the large industrial area and hinterland which it serves.

EXPANSION IN INTERNATIONAL TRADE

During the past 80 years, world trade has been expanded and revised until it has become a major factor in the economy of Oakland. Probably the most complete change in the ports' trade with the nations of the world has been effected since the Second World War during which Oakland was one of the largest military supply areas in the world.

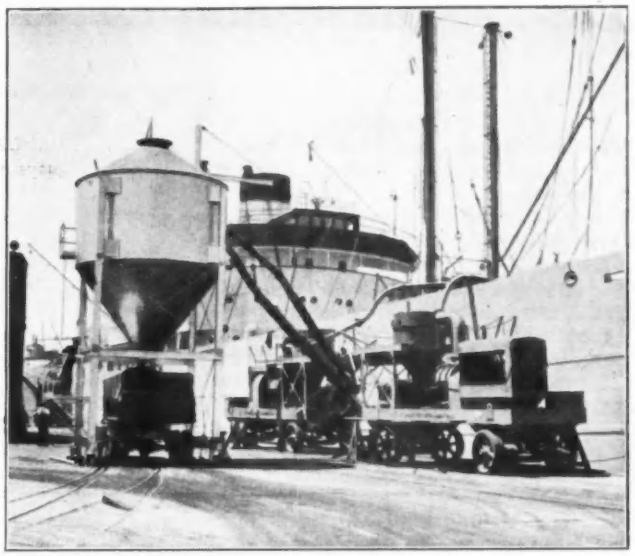
Chiefly responsible for the marked change in types, quantity and quality of commodities imported and exported through the Port of Oakland are the growth of population and industry in the bay area community, the lack of dollars in foreign countries, and the federal government relief programme. This latter has caused a heavy movement of lower price bulk commodities which may be classed as necessities of life—i.e., dried fruits and rice, replacing higher priced canned fruits, powdered milk rather than the heavier and more expensive canned milk. At the present time practically all exports are government controlled either as relief shipments, or by strict regulation designed to conserve United States stocks.

In 1900 international trade through the Oakland-San Francisco Customs District was $78,238,000. During the post war year, 1946, exports and imports rose to $402,377,000 and in 1947 reached a peak of $611,900,000. Figures for 1949 are as yet unavailable.

Export commodities which have been shipped through the Port of Oakland since the war in large amounts are dried and canned fruits, bulk petroleum and its many by-products, machines and parts, fertilizer, salt, raw cotton, lubricating oils and greases, barley, drugs and chemicals, fresh fruits, lumber, and canned vegetables.

Principal imports are coffee, copra, whiskey, burlap, tung oil, paper, tea, pineapple, canned fish, coconut, bananas and ores. Two of the most important items at the port have been paper, mostly newsprint, and copra. The newsprint is imported from Scandinavian countries and British Columbia.

Copra, the sun dried meat of the coconut, is imported from Pacific Islands, and since the war, has been shipped in bulk rather than sacks for discharge at the port by mobile copra blowers which transfer the copra from ship to rail car, truck or storage bins, operating very much like a giant vacuum cleaner. Copra has been the largest single item imported in recent years. It accounted for nearly 30 per cent. of imports in 1947—201,000 tons—and it is estimated that approximately 40 per cent. of this nation's copra comes in through bay area ports. The copra is processed by bay area firms and the oil used in the manufacture of a myriad of products—mayonnaise, paint, varnishes, soap, margarine, nylon, to mention a few.



Copra Blower Discharging Vessel.

In addition this area is prominent in the manufacture of calculating machines, diesel engines, automotive parts, agriculture and canning machinery, industrial filtering equipment, numerous other types of machinery and equipment, paint products—all of which are exported in large quantities.

Since the early days when the first ships sailed through the Golden Gate, bringing lumber for houses, food, tools and all the items for a new country, down to the present time when exports far exceed the commodities imported, trade with other nations has played an all important part in the bay area.

Hundreds of bay area businesses are directly or indirectly concerned with international trade. More than 100 steamship lines serve ports all over the world from San Francisco Bay, and here too are the exporters-importers, trade associations, allied ship repair agencies, freight forwarders, railway and air transportation companies, custom house brokers, admiralty attorneys, to say nothing of the countless firms that produce for export and process the imports.

One cannot discuss world trade without mention of the Oakland Municipal Airport where there is a constant increase in the amount and types of cargo now being flown to all parts of the world. Air transportation is proving increasingly expedient for perishable items, extremely valuable commodities, rush orders and numerous other items.

World trade in this area will continue to grow with the community, and as foreign countries stabilise their economies, and the need for the huge European relief programme subsides, there is no question that trade will be resumed by private enterprise to an extent far surpassing that of the pre-war years.

Modern Steel and Concrete Transit Shed.

HARBOUR PROJECT FOR DUTCH NEW GUINEA.

The Governor of Dutch New Guinea recently visited Holland for consultations with the Government regarding a proposal to build a new harbour at Hollandia. It is understood that the plan has been approved, and an expert from the Ministry of Reconstruction is expected to leave for New Guinea at an early date, for further study and investigations. If the project goes through according to plan the new harbour will be completed within three years.

Masthamnen Harbour, Stockholm

Construction of a New Quay

By Dr. PAUL LEIMDORFER, M.A.S.C.E.
(Head of Department of Quays and Docks Harbour Board of Stockholm)

INTRODUCTION

IN 1941 the City of Stockholm decided to start the first stage of its largest quay, of a total length of 840 feet and a depth of 32.5 feet, enabling direct docking of the American Victory boats. The ground consisted of waste rock fill containing granite blocks chiefly of a size of 30-40 cu. ft.

This rock fill formed a layer of about 50-70-ft. thickness leaving beneath, however, a 10-15-ft. layer of soft clay that caused permanent settlement. Fig. 1 and 2 show the standard cross-section and plan of the majority of the quay, but there is another section, parts 2 and 3, which, over a length of roughly 65 metres, consists of a quay about 30 metres wide, supported on three groups of piles and a small retaining wall at the rear.

STEEL BOX PILES

Owing to the great depth to bed-rock we decided to carry out a platform quay supported by piles. We constructed steel box piles by welding together two deep-arch piling units, provided them with heavy shoes and a point of specially hardened steel of 4 inch diameter. The shape of the shoes as well as points were decided by taking into account the results of extensive test work. For part 1-4 we used German "Union" box profiles giving a weight of 104-lb. per lineal foot, for part 5-9 English Larssen piling of section 4B weighing 115-lb. per lineal foot. The German piles were of quality "Resista" with ultimate strength of 38 tons/sq. in. the English piling material had an ultimate strength of 29 tons/sq. in. Both had a copper content of about 0.3 per cent to retard corrosion.

The piles were driven through the large blocks by a single-acting steam hammer, type Menck-Hambrock with a ram weighing 8,800-lb. The longest pile was 113 feet, the average penetration per blow 0.77-in. and average deviation of the top 0.92-in.

After having been driven to practical refusal and thus reached bed-rock each pile was examined with an electric lamp whereby the tightness and straightness of the piles were checked and registered. Of the 247 piles, giving a total length of more than 3½ miles, we had only two failures apart from the two test piles. Piles which proved tight and undamaged were filled with concrete. The piles were capped by a common reinforced concrete plate serving as a base for the superstructure.

The only reinforcement the piles received were four ¾-in. bars at the top of the piles in order to increase connection between capping and pile.

The bearing capacity of a pile was determined by the following two limit conditions:

(a) the maximum ground pressure of the point,

(b) the concrete area when taking into acount the maximum steel corrosion in the proximity of the water level.

The permissible local ground pressure on sound granite was checked by tests and found to be about 17,300-lb. per sq. in. Thus a point of 4-in. round steel was to carry about 95 gross tons. The concrete area of the piles was about 185 sq. in. resulting in a concrete pressure of 1,120-lb. per sq. in. for a load of 95 gross tons.

When computing the beam system the useful life of the box-piles was divided into three parts:

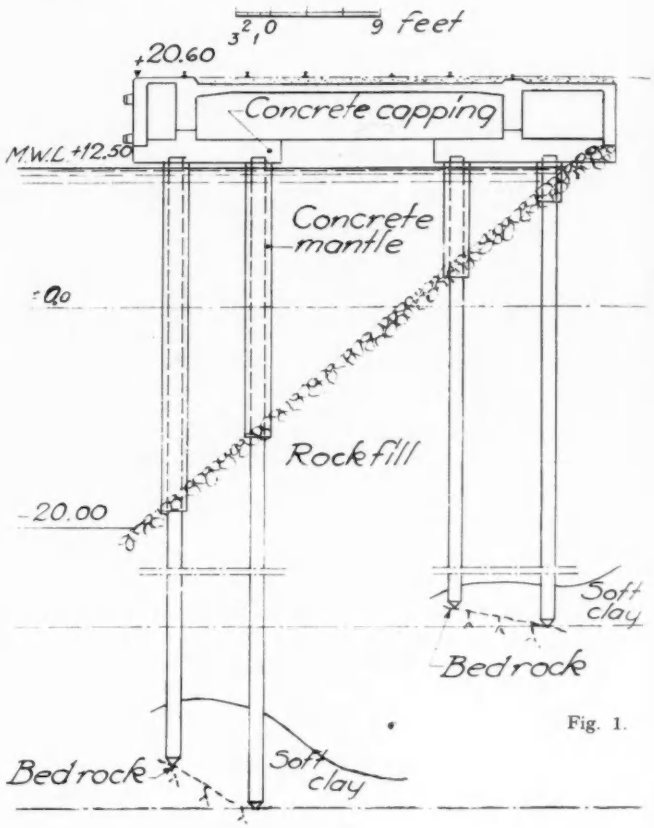


Fig. 1.

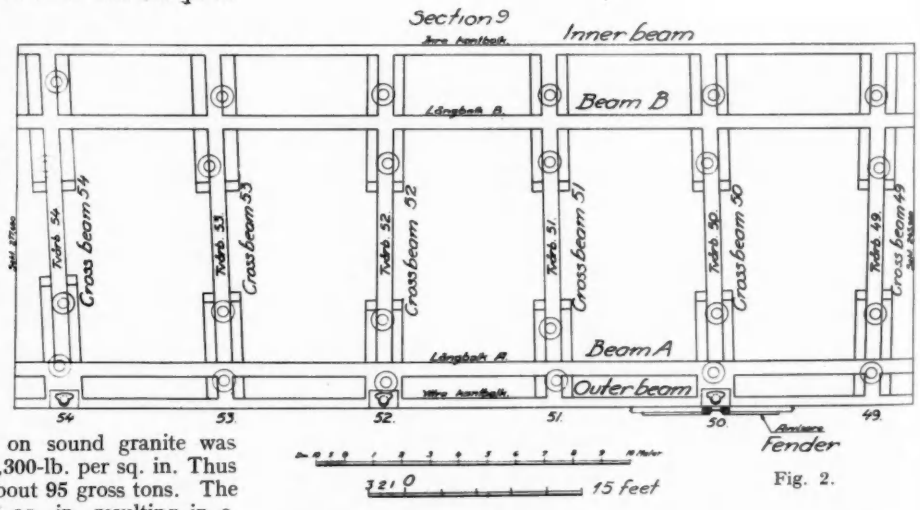


Fig. 2.

(a) Youth: when the moment of inertia is composed of both the whole steel and concrete area, the unstabilized rock filling acting in passive friction (assumed angle of friction $\phi = 45°$) and increasing the load of the pile;

Masthamnen Harbour, Stockholm—continued

New Quay, Masthamnen Harbour, concreting slab of part 2 and driving piles for part 3.

(b) Middle age: when one half of the steel area disappeared by corrosion. Simultaneously, however, tendency to settlement of the fill has diminished and partial stabilization granted (assumed $\phi = 75°$);

(c) Old age: when there is no passive friction at all ($\phi = 90°$) and no steel left at all. Now the pile is a pure concrete one.

To increase useful life of the steel and protect the upper part of the piles they were provided with a reinforced concrete mantel down to the bottom. Minimum thickness of concrete was 4 inch (Fig. 1 and 2).

CONCRETE BEAMS

The piles were connected by main cross beams of reinforced concrete, centre to centre about 20 feet. The longitudinal beams —supporting the tracks of the portal cranes—represented thus the secondary structure unit. The computation of the cross and longitudinal beams was designed by taking into account the distribution of forces acting upon the system of elastic supports given by the piles. The load P to be carried by a certain pile is a function of the amount of inertia I_x, and modulus of elasticity E_x, of the pile, moreover, of the span between two adjoining piles l, the height of the pile h and a constant c giving the size of the elastic settlement of the top of the pile as a result of the unity of load. Thus it can be written as follows:

$$P = f\left(\frac{I_x \; E_x}{l^3} \quad . c \; . h\right)$$

As the moment of inertia decreases with increased corrosion changing at the same time the proportion between steel and concrete area the equivalent modulus of elasticity must be also considered as variable. In order to receive equal maxima of pile loads, as far as possible, determination of the final position of the piles was thus to be computed by trial and error in connection with computation of the cross beam support reactions. The solution became a rather intricate one considering the number of variable terms.

The earth pressure of the fill acting upon the longitudinal inner beam is taken up by ordinary concrete anchor blocks and tie bars fastened to the cross beams.

SLAB

The concrete slab was computed by taking into account the stiffness of the concrete beams against twisting (torsion); I mean principally the cross beams giving the main direction of support. In this way there is no ordinary continuous slab to be designed but a slab which is fixed into the cross beams in a variable degree depending principally upon the distance from the ends of the cross beams. At these ends the fixation percentage is nearly 100 per cent, i.e., the slab is completely fixed as the relatively stiff longitudinal beams and pile cappings hardly allow any twisting of the cross beams. In the middle of the cross beam the percentage of fixation decreased to 84-92 per cent. Hence the slope of the deflection line—and as a consequence the line of the bending moment—will prove to be quite different than with the usual continuous slabs. At the support of the cross beam we get the following relationship:

$$M_s = \frac{\phi_o}{\phi_1} \; \frac{1}{1 + \frac{\alpha s}{\phi_1} \operatorname{tg} h \; \lambda}$$

At the centre of the beam we get $m_c = \dfrac{Ms}{\cos h \; \lambda}$

Where: M_t = unit of twisting moment per lineal foot of the cross beam;

ϕ_o = slope of the deflection line of the freely supported slab at the end, due to unit load;

ϕ_1 = slope of angle of the freely supported slab at the end, due to unit moment at both ends;

α = slope of the angle of the freely supported slab at the end, when applying M = 1 at both ends;

$s = \sqrt{g \; I_t \; \phi_1}$ giving the equivalent length of span;

g = shear modulus of longitudinal beams;

I_t = moment of inertia in torsion of longitudinal beam;

$\lambda = \dfrac{L}{2s}$;

l = span of slab;

L = span of longitudinal beam.

It will be noted that two railway tracks or an equivalent surcharge of about 650-lb per sq. ft. were carried by a relatively weak 8-in. slab on an area of about 600 sq. ft. without excessive beam support.

CRANE WAY FOOTINGS

As mentioned two longitudinal beams centre to centre 29.4 feet were intended for carrying the portal crane tracks, but owing to unforseen circumstances some semi-portal cranes had to be used on a short section of the main quay, that is to say the inner leg of the crane (actually intended to rest on the eaves of a shed), had to be carried upon an elevated crane track, supported on columns on the ground, while at 46.7 centres the outer leg resting on the quay. This decision was made after the piles had been driven and part of the concrete poured. A special footing was therefore necessitated, consisting of a ground plate and four wings of reinforced concrete, at the centre of the cross being a space for the steel column. With regard to possible horizontal dislocation and vertical subsidence of the fill it was necessary to enable future adjustment of the column position in both longitudinal and cross direction as well as compensation of probable settlement.

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Dock and Harbour Joint Engineering Committee

To Consider Standardisation of Engineering Products

On the 1st April, 1949, the Ministry of Supply invited the Docks and Inland Waterways Executive to nominate representatives to discuss the standardisation of engineering products, and the Dock and Harbour Authorities' Association were also asked to be represented.

A meeting was held on the 3rd May, 1949, when a Joint Memorandum was prepared by the Executive and the Association. This recommended the setting up of a joint committee to consider what steps could usefully be taken to determine whether any reduction in the variety of the engineering products, in which they are interested, is desirable and to discuss matters of common interest. This suggestion was also embodied in the Report of the Committee for the Standardisation of Engineering Products, under the chairmanship of Sir Ernest Lemon.

It was subsequently decided to invite the Railway Executive to be represented, and at a meeting held on the 5th January, 1950, between representatives of the Association and the two Executives it was agreed that the constitution of the Committee should be four representatives each from the Dock and Harbour Authorities' Association and the Docks Engineers' Committee of the Executives.

The first Chairman to be appointed by the Dock and Harbour Authorities Association and then alternate yearly.

Joint Secretaries to be appointed. Meetings to be held quarterly unless any urgent matters require to be discussed and reported upon.

The terms of reference of the Committee are as under:—

(1) To study the development of dock and harbour engineering as regards both maintenance and construction by means of the exchange of information and experience and the instigation of research into the experimental work in connection with problems that arise;

(2) to keep under review the extent and variety of user of engineering products required for dock and harbour installations and to determine whether any reduction in the variety of such products is desirable;

(3) in furtherance of the before-mentioned objects, to consult and co-operate by means of meetings, correspondence, and inspections and to co-operate jointly with, or enlist the assistance of, such outside organisations, generally or for any particular purpose, as shall be mutually agreed.

The members of the Committee are:—

Dock and Harbour Authorities' Association

Mr. R. J. Hodges	General Manager, Mersey Docks and Harbour Board.
Mr. D. C. Milne	Chief Engineer, Manchester Ship Canal Company.
Mr. A. B. Porter	Engineer-in-Chief, Mersey Docks and Harbour Board.
Mr. A. Thomson	Engineer, Clyde Navigation Trust.

Docks and Inland Waterways Executive

Mr. W. Mackenzie	Chief Engineer for Docks, Middlesborough, Hartlepools and Humber.
Mr. J. T. Evans	Research Officer.

Railway Executive

Mr. A. Dean	Chief Officer Engineering (Works).
*Mr. J. H. Jellett	Docks Engineer, Southampton.

Joint Secretaries

Mr. L. J. H. Horner	Dock and Harbour Authorities' Association.
Mr. W. H. Price	Docks and Inland Waterways Executive.

* Now under the Docks and Inland Waterways Executive.

The Docks and Inland Waterways Executive, in conjunction with the Railway Executive, had previously set up a Dock Engineers Committee who direct their attention to the following matters:—

Developments in Dock Engineering as regards both maintenance and construction: the formulation of proposals for the execution of any special research considered desirable from time to time and for the maintenance of contact with research work having a bearing on Dock Engineering carried out for either Executive or by outside organisations within the framework of the B.T.C. and Executives' Research Organisation as shall be laid down.

Exchange of views on aspects of layout, design and methods of execution of work (including plant) which may be of common interest. With consideration of possible standardisation, co-ordination and inter-changeability.

Co-ordination of the use of large units of dredging and other appliances and equipment.

Election of Port Commissioners

The following announcements concerning the election or reappointment of Port Commissioners have been received.

Clyde Navigation Trust.

Mr. Barclay Hogarth has been elected Chairman for the ensuing year, and Mr. John MacLean, Vice-Chairman.

The following seven members were re-elected to the Clyde Pilotage Authority: Mr. Barclay Hogarth, Sir Thomas Dunlop, Mr. Charles Connell, Mr. Robert Galloway, Mr. L. Harper Gow, Mr. Ian C. Macfarlane, and Mr. George A. Workman. Mr. Hogarth was re-elected member for the West of Scotland on the Executive Committee of the Dock and Harbour Authorities' Association.

Tees Conservancy Commission.

At their Annual Meeting last month, Mr. G. West Byng was re-elected Chairman of the Board of the Tees Conservancy Commissioners for the sixth year in succession.

Tyne Improvement Commission.

Mr. William A. Souter, who has been Chairman of the Tyne Improvement Commission for a period of five years, relinquished that position at the Annual Meeting which was held recently. He is succeeded by Mr. B. Eliot Common, who has been Deputy Chairman since January, 1949. Mr. Arthur G. Everett, J.P., was elected to the position of Deputy Chairman.

Dundee Harbour Trust.

The following were elected at the annual general meeting of Dundee Harbour Trustees: Chairman, Mr. A. Lickley Proctor; Vice-Chairman, Mr. James S. Nicoll; Finance, Mr. Alexander Smith; Works, Mr. C. B. Walker; Tay Ferries, Mr. F. J. D. Buist; Lighting and Buoyage. Mr. J. R. Cowper, who was also re-elected Chairman of the Pilotage Committee.

Masthamnen Harbour, Stockholm

(continued from previous page)

The steel column was fixed in its position by wedges that were accessible from any direction. The space around the columns was covered by a removable concrete slab giving protection against rain water.

Penetrating water was concentrated to the middle part by a sloping floor and drained by pipes.

Adjustment of the column is to be carried out as soon as

(a) the difference in height between two neighbour columns exceeds 1 inch;

(b) the horizontal displacement of the column top exceeds 1.6 inch.

The above quay construction was carried out by the Building Department of the Harbour Board of Stockholm, a City Authority (H. Jansson, chief engineer, A. Wickert, head of design).

Marine Services of a Port

Some Notes on the Types of Craft Engaged

By Capt. H V. HART, R.N.R. (ret'd.)

THE provision of the various marine services, necessary for the efficient operation of a large Port, requires the maintenance of a considerable number of craft of widely divergent types, varying in size, from a 10,000 ton dredger to a diminutive harbour launch. All these craft, in the performance of their entirely separate functions, collectively form a co-ordinated entity, which enables the Port to provide essential amenities and safety, for vessels making use of it.

Ports afford considerable contrast in importance, size and range, from those comprising but a few acres of dock space to others of immense area, and naturally, therefore, the requisite marine services vary in direct relative proportion.

In addition to those marine services, which are administered and operated by the Port Authority as part of its organization, for example harbour master's inspection and patrol service, hydrographic survey, dredging and salvage, there are also several essential ancillary services. These include:—pilotage, customs, health, fire protection, tugs and passenger tenders, police, etc., which are usually under the administration of municipal and other authorities, or, as to certain of them, under the aegis of private enterprise.

The various types of craft, required for the many services of a Port, depend upon the diverse geographical, hydrographical and local conditions, each port necessarily possessing its own individual characteristics and consequent requirements, and it is proposed, therefore, to exemplarize the case of one of the largest Ports under the principle of:—" The lesser is included within the greater." The Port of Liverpool, chosen as an example, contains within its Authority a large area of open sea, with many sandbanks, through which long sea channels lead into a sheltered river, from which ingress is obtained through River dock entrances, into the several Dock systems. A Port so situated obviously requires marine services of a far more extended and complex nature than those occupying more convenient geographical situations and in close proximity to deep water approaches. In the former case it may be said that the maximum number of marine services are required, and that these will cover the requirements of all ports, with the elimination of certain services unessential for the lesser ones.

Some of these various services, can best be appreciated by considering an imaginary approach from seaward.

Immediately outside the area of the Port is stationed a lightship, which provides navigational assistance to vessels, prior to their entry into the buoyed channels. This area also constitutes a Pilotage station, where outward bound vessels discharge their pilots.

The lightship, recently entirely modernized, is stationed outside the approaches to the port, and particulars of this vessel are:—Length 108 feet. Beam 24 feet. Depth 12 feet. Light—electric 124,000 C.P., visibility 12 miles. Horn—diaphone. Compressors —2 in number, driven by 2 diesel engines. Generators—2 diesel. Its equipment also includes radio-telephony.

The vessel requires replacement by a duplicate, during biennial periods of withdrawal for overhaul, fortnightly attendance for relief of crew and occasional attention to maintenance of moorings, etc.

In other ports of the United Kingdom the majority of the lighting, buoying and marking is carried out by Trinity House.

PILOT CRAFT

The first contact is made, some 40 miles to seaward of the actual approaches to the Port, with the Pilot boat, which provides compulsory pilotage from that station for all inward bound vessels.

The pilotage service, though one of the most important, is not one which is administered and operated by the Port Authority, i.e., Pilots are not its employees. These services are either under the administration of Trinity House, which is constituted as the statutory Authority for Lighting and Pilotage Services in the United Kingdom, or the local Pilotage Authority, and in the latter case particularly, function in close co-operation with the several marine services of a Port.

The varied pilotage services which are in existence for duties in connection with the ports of the United Kingdom, present a pageant of craft of infinite diversity. The former beautiful little cutter and schooner-rigged sailing craft have long been displaced by powered vessels of various sizes and specifications, as most suitable for the local conditions, etc., under which they are required to operate. Not infrequently, too, it becomes obligatory for such specifications to be actuated by economic necessity. Craft, ranging from open launches, and extending through a whole series of converted drifters, trawlers, motor and other similar types, with accommodation for the pilots, reach their zenith in the form of the latest type of large, modern, high-powered vessel of to-day, as engaged in the services of the largest ports, which is capable of accommodating up to 40 pilots, in addition to the crew. All these types of craft play a worthy part in their several contributions to one of the most essential services for the efficient operation of a port.

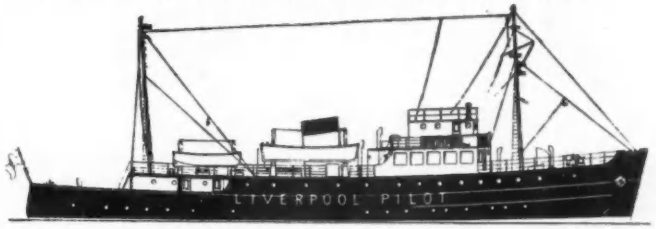


Fig. 1. Profile Drawing of new Pilot vessel under construction.

Fig. I shows a profile drawing of a new pilot vessel now under construction and nearing completion to the order of the Pilotage Authority of the Port of Liverpool. Particulars of the vessel are:—Length 165 feet, beam 31 feet, draught 11 feet, tonnage (gross) 742, speed 12 knots. She is a single screw ship, and in order to provide economical maintenance, diesel-electro propulsion has been installed. There are 2 tandem engines, capable of developing 375 B.H.P. at 360 volts. In addition to driving the 360-volt generators for propulsion, each engine is coupled to an 80 KW, 200 volt D.C. generator, in order to provide the necessary heating, lighting and auxiliary power for the vessel The main propulsion motor is a 920 B.H.P. single armature unit which is directly coupled to the propeller. Her equipment includes an " echo " sounding machine, radar and radio-telephony. The accommodation is of an exceptionally high standard and provides for 30 pilots, in addition to her crew.

HYDROGRAPHIC SURVEY CRAFT

The sea channels are buoyed and continuously surveyed, entailing constant services of a special Buoyage and Surveying craft, to ensure accurate positioning and efficient lighting and the maintenance of the requisite depths. These channels also require a constant and considerable amount of dredging, in which service several large suction dredgers are maintained in operation. Involved in the maintenance of these channels is a special problem in the form of the revetments or training walls which are established along their marginal sides, with a view to avoidance of encroachment of sand into the channels and consequent decrease of depth and proportionate increase in routine dredging. The original construction and alignment of these training walls required

Marine Services of a Port—continued

the exercise of great care in surveying, in order to ensure the necessary accuracy in conformity with the plans. Construction also necessitated the conversion of several hoppers, to stone carrying capabilities, with frequent attention thereafter to afford compensation for a very considerable amount of sinkage.

The River requires periodic surveying and especially in the vicinity of the numerous dock entrances and stages, the former of which are particularly susceptible to silting, and this service is carried out by a specialized type of small craft suitable for operation in severely restricted areas. The dock entrances also entail constant and, in some cases, continuous dredging, on which service suction, bucket and grab dredgers are employed, together with their attendant fleet of hoppers, the latter to carry the excavated silt to the dumping grounds, situated outside the Port.

Particulars are given below of a type of craft specially designed for surveying and general conservancy duties in sheltered waters, and in restricted areas where good manoeuvrability is essential for making close hydrographic examinations over sunken wrecks, etc., and for the provision of river transport facilities, etc.

The principal features of this vessel are:—Length 37 feet, beam 9 feet, draught 3 feet, speed 8 knots. The propelling machinery, which is totally enclosed in a steel structure in the after end of

Fig. 2. Port of London Authority launch " Havengore " for survey work.

the craft, consists of a single 4-cylinder diesel engine. She is of special strong construction and fitted with a " kitchen " type of rudder, which enables her to turn in her own length. Electric lighting is installed and a combined day cabin and " plotting " room, toilet, galley, etc., provide the necessary accommodation. Equipment includes—echo sounding machine (boat type), patent (Sutcliffe) sounder, and platform for hand leading—the two latter being for use in extremely shallow water.

A small vessel has been recently constructed to meet special requirements for surveying in close and shoal waters where draught constitutes an important and limiting factor. Her size provides both good manoeuvrability and the necessary seaworthiness to operate under conditions which preclude the use of " boats," and, at the same time, render the employment of larger vessels uneconomic. Her deck equipment also makes her suitable for general conservancy duties. Particulars are:—Length 80 feet, beam 20 feet, draught 6 feet, speed 10 knots. The propelling machinery consists of 2 diesel engines of the uni-directional type, which are magnetically coupled to twin engine reverse reduction gear. This method effects a definite saving of direct reversing gear on the engine; and in the air compressors and storage required. This arrangement is specially adaptable to the bridge control which has been fitted. Electrical power is provided by flexible couplings between the engines and 2 generators. The steering gear is operative by both hand and electrical power. Her navigational equipment includes an echo sounding machine and radio-telephony. The necessary day accommodation, which is of a high standard, is provided for surveyors (aft) and crew (forward).

Fig. 2 shows a photo of another type of modern surveying vessel, in use in the Port of London. Particulars are:—Length 112 feet, beam 18 feet, depth 5 feet 3 inch, speed 12 knots. She is a mahogany carvel-built, double skin, twin screw vessel. The engines are two 6 cylinder, 2-stroke gas oil, of 225 H.P. each. She is equipped with an echo sounder, and is employed on surveying duties in estuarial waters.

DREDGERS

The question of dredging constitutes a major operative and economic problem for most Port Authorities, and particularly so in the case of estuarial ports, the approaches to which may consist of long channels, through areas of water in which serious accretions of sand, in the form of banks, exist, sand from these banks almost invariably encroaches in the form of shoaling upon the channels, the only normal remedy for which consists in dredging, although, as in certain ports, the construction of revetments or training walls on the marginal sides of channels may be expected to result in a material decrease of the necessary maintenance dredging. In one such large port—Liverpool—conforming to the above geographical conditions, the annual amount of sand and silt removed by dredging averages over 10 million tons and the total removed during the last 56 years amounts to over 500 million tons. This menace of siltation has been increased by wartime restrictions whereby dredging was necessarily reduced to the minimum essential for the maintenance of navigational access to the port. As a result of the war too, the services of many dredgers were lost, either temporarily or permanently by requisition and enemy action. The replacement of depleted fleets of dredging craft has perforce occupied a considerable period of time and proved a serious economic factor in port finance. The problem of dredging, therefore, presents a major operation among the Marine Services of a port, and necessitates the provision and maintenance of a large dredging fleet comprising all the various types of craft requisite to deal with the different situations and conditions. These several types differ greatly in both size and complexity, and range from a 500-ton capacity Hopper to a 10,000-ton capacity dredger, and elaborately equipped bucket and rock cutting dredgers. They are each operated for their own individual functions, which approximately may be classified as follows:—sea bars; sea channels; shoals; river dredging; etc., by suction dredgers, river, dock entrances, etc., dredging by bucket dredgers and Dock dredging, etc., by grab dredgers. In

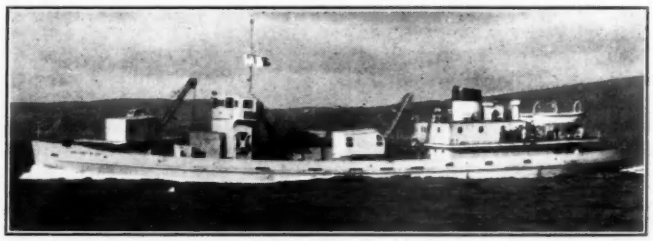


Fig. 3. A recently built Grab Hopper Dredger.

certain cases, as in the construction of new dock entrances, or alteration of existing ones, it becomes necessary to employ the services of rock cutting dredgers.

Most of the above types of craft necessitate the attendance of a fleet of hoppers for the transport and dumping of their loads. In some ports certain of the various dock entrances, owing to special physical and tidal conditions become subject to unusual eddy action, and other abnormal factors which cause an excessive amount of siltation and necessitate a high volume of routine maintenance dredging. In such circumstances dredging is sometimes assisted by sluicing operations, through the entrances. In earlier days it was commonly found expedient to operate dredging services by hopper barges of 500 tons capacity fitted with centrifugal sand pumps which filled themselves with silt and then proceeded to the dumping grounds. In dredging, as in all Marine Services, each individual port possesses its own particular problems and requirements, and these vary considerably in proportion to the size of the port and its own geographical, hydrographical and tidal conditions, and, therefore, only a bare generalization of requirements for a dredging service is possible.

The largest dredger ever constructed was built early in the present century and was a self-propelled turn-screw suction dredger, of 10,000 tons sand carrying capacity, which she was capable of loading in 50 minutes from a maximum depth of 70 feet. Her loaded draft was 23 feet.

Marine Services of a Port—continued

Fig. 4. Port of London Authority Harbour Service Launch.

The Port of Liverpool employs a suction dredger, with a hopper capacity of 3,500 tons of sand, which she is capable of filling in 50 minutes from a maximum depth of 65 feet. The vessel is mostly employed in the sea channels of the port, with intertidal periods of work in river dock entrances.

Fig. 3 is a photo of one of a number of recently built hopper-grab dredgers. These vessels operate on the new electric principle of the controlled constant current system, not hitherto in use in this country. Briefly this system consists of the use of an appropriate number of generators which are interconnected in series and in conjunction with several various sized motors. The advantage of this system being that any desired proportion of the total power available may be used at any time, either for propulsion or auxiliary purposes and obviates the need for large generating sets the full use of which only occurs during periods when high power becomes necessary. In this vessel 3 generators are driven by two 12 cylinder V-type oil engines. The main deck machinery consists of 3 grab cranes of 62 h.p. each, and two 50 h.p. winches. The accommodation is of the highest possible standard and includes air conditioning installations; hot and cold running water, etc., the former being supplied by a special oil-fired steam boiler. The principal dimensions are:—Length 237 feet O.A., beam 40 feet 6 inch, draught 14 feet 3 inch, capacity 13,500 tons of sand.

In those ports where the normal amount of routine dredging is small and it proves uneconomic to maintain a fleet of dredgers and staff for the purpose, the requisite dredging is carried out by one of the many private firms of dredging contractors. In cases, also in those ports which do not possess their own dredging plant, outside dredging is employed for the furtherance of any new scheme projected by the Port Authority, in which dredging is involved, i.e., special widening and/or deepening of a channel; construction of, and excavations for, a new dock entrance, etc.

PORT HEALTH LAUNCHES

A typical and suitable type of craft for this purpose is embodied in the following particulars, relating to a vessel for many years in service in Liverpool:—Diesel engines, length 63 feet, beam 14 feet, draught 6 feet, speed 12 knots. The necessary accommodation is provided for officials and crew. In this particular case it was found possible to combine both Health and Fire Services in the use of the single craft employed in the latter service, with the consequent abolition of the launch in the service of the former, and substantial economy was effected thereby.

The above type can also apply to the Custom's Service with a slight increase in accommodation for the greater number of officials engaged. The majority of these types of craft in Liverpool are at present steam propelled.

HARBOUR SERVICE CRAFT

The Harbour Master's duties in most ports are continuous day and night, for much has to be watched by him and his staff. They are far too numerous to be set out in these notes, but broadly it is his duty to ensure that the various Harbour and River byelaws are properly observed. For the convenience of the Harbour Master or other official engaged in these duties it is necessary to supply a launch or craft of suitable type.

The special requirements for these craft depend so largely upon the geographical position of each port, and the local conditions pertaining thereto that it is impossible to standardize any particular type as a Harbour launch. Briefly such craft should possess the qualities of:—Requisite speed for operation in tidal waters; handiness in narrow waters; seaworthiness for emergencies; and limited accommodation far the use of officials and crew. A type of craft suitable for fulfilling this general specification is a hard chine, petrol-driven vessel of approximately 24 feet in length, with a speed of 12 knots.

Fig. 4 shows a photo of a Harbour Launch suitable for service on an estuarial river, with an appreciable tideway. Particulars are:—Length 66 feet, beam 15 feet, depth 4 feet 3 inches, speed 10½ knots. She is a mahogany, carvel-built, twin screw vessel, with a 6-cylinder 100 h.p. diesel engine. Suitable accommodation is provided for officials and crew.

SALVAGE VESSELS

In most ports there remains, as a war legacy, the necessary operations of reduction and dispersal of vessels sunk by enemy action. For these purposes it is often advisable to employ craft suitably equipped for the storage of explosives which are moored in approved and isolated positions, within the port area, and convenient to the scene of operations. A suitable type of craft for this purpose is obtained by conversion, from (say) a discarded lightship. The same type of craft provides a suitable "Watch vessel" for the close and distinctive marking of wrecks sunk in narrow waters and in areas in which a heavy volume of traffic is navigating. It also makes it possible to exhibit the requisite fog signals, and they should be fitted with a full equipment of signals, lights, etc., and normally would carry a crew of two.

For a port such as the example, one of the primary requirements is a vessel, or vessels, specially designed and equipped for carrying out a combination of services, comprising:—Surveying, buoyage, salvage, fire fighting, and general conservancy duties. A vessel suitable for this combination is difficult and rarely feasible to acquire by conversion from other types of craft, and must be built. In designing the vessel due consideration must be given to various factors which may be likely to affect her conditions of employment. These include:—Weather conditions for seaworthiness, tidal conditions for speed, size for manoeuvrability in restricted waters, draft for local depths, accommodation for additional personnel, propulsive power suitable for maximum safety and performance of duties, types of auxiliary power as alternatives, disposition of weights to allow for heavy lifts, increased scantling with necessary reinforcements to counteract heavy strains, clearance of superstructure to allow for overside towage, and amount of equipment, etc.

Fig 5 is an illustration of this type of vessel, recently constructed, for the Port of Liverpool. She was designed to operate in all the above mentioned services, and under all conditions and circumstances considered likely to occur. For carrying out her surveying

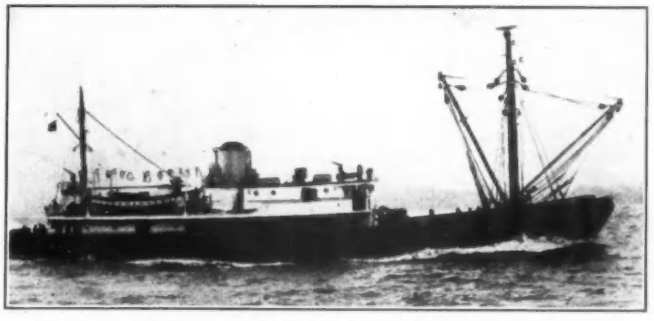


Fig. 5. New "Combined Services" vessel for Port of Liverpool.

Marine Services of a Port—continued

service, she had to be suitably equipped and of reasonable dimensions for manoeuvrability in narrow waters and in traffic. Her buoyage requirements included the ability to hoist and board buoys, ranging from 4-12 tons in weight; transport 4 of these simultaneously; transport and operate 360 fathoms of heavy moorings and tow lightships, etc., to and from their respective stations. Salvage service might necessitate a total lift of 100 tons up to the bows and transportation to another locality.

The following are her particulars:—Twin-screw oil-burning vessel, length 165 feet, beam 34 feet, draught 10 feet, speed 14 knots, gross tonnage 671. She is propelled by 2 triple expansion engines and steam is supplied by two 3-furnace oil-fired cylindrical boilers, designed for 200 lbs. pressure. Total I.H.P. is 1,300. The vessel is also equipped with electrical power, consisting of two 290 KW diesel generators producing the normal voltage of 220, but is capable of generating up to 300 volts by shunt regulation and excitation. Connections on the main switchboard and on deck are available for the supply of electrical power to other vessels. In addition there are two 25 KW, 110 volt generators, steam and diesel driven respectively, for the supply of the necessary lighting, etc., for night operations.

Two fire pumps are situated on the main deck beneath the bridge and are each 340 H.P. and capable of discharging 6 tons of water per minute through 2 monitors on the bridge deck, fitted with 2 inch nozzles. Additional fire fighting appliances include 7 fire guns mounted on swivels on each side of the deck. A special arrangement of sprayers to cover the entire vessel is operated from the connections of each monitor. The deck auxiliaries include a steam driven winch capable of raising a weight of 100 tons to the bows, for which purpose the mast is slightly off-centred, and the deck is fitted with the requisite bollards, fair leads, etc., in appropriate positions. An air compressor is installed for diving operations and a low pressure, large capacity air compressor is also fitted for the supply of compressed air to wrecks, etc., during salvage operations.

The form of superstructure possesses an unusual feature, in its absence of side support to its overhung form. The main derrick has a lifting capacity of 25 tons. The navigational equipment includes echo sounder, radio telephony and radar. Accommodation for officials is provided on the bridge deck. The ship's complement are berthed aft, with additional emergency accommodation for salvage personnel. All accommodation possesses the latest amenities for comfort.

The vessel carries a complete " self contained " equipment of salvage plant and gear, including a large number of various sized portable salvage pumps, ranging in size up to 12 inch diameter.

Fig. 6 is a profile drawing of a hopper which, as a war expediency, was converted into a combined services vessel, with special relation to salvage work.

For these purposes the entire internal hopper and all dredging appliances were removed, together with the fo'c'sle head and the bow was fitted with a heavy casting. The necessary hold space was adapted to meet the requirements of accommodation for personnel.

A short bridge deck was built for the stowage of boats. Her long fore deck, which was fitted with the requisite bollards, fair leads, etc., proved particularly convenient for transportation of buoys, working of heavy moorings, and for heavy lifts over the bows. The heavy (off centred) mast was fitted and equipped with 2 derricks of 3 and 25 tons lifting capacity respectively.

Salvage officials, crew and emergency salvage personnel were accommodated forward, and the ship's officers aft. Her hold was

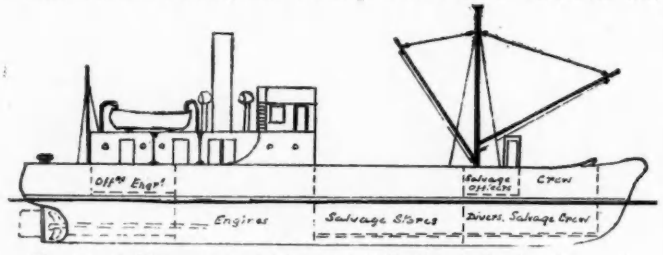


Fig. 6. A Hopper converted into a " Combined Services " vessel.

Fig. 7. Fire Float at the Port of Liverpool.

fitted for the stowage of a full equipment of salvage plant and gear and a small workshop was also provided.

Her navigational equipment included echo sounder, radar and radio telephony. The radar scanner was installed on the foremast head, and the installation included a relayed extended display to the bridge. Her speed of 9 knots proved, however, insufficient and her length of 197 feet rendered her difficult to manoeuvre satisfactorily in narrow waters.

A vessel designed for combined salvage, fire fighting and mooring, etc., services, and based on the Port of London Authority, has special bow fittings, give a lifting capacity of 90 tons, on the bow davit, and 120 tons by combined use of the 2 bow sheaves. The vessel has dimensions of: Length 151 feet, beam 27 feet, depth 15 feet, draft light 8 feet (mean), draft loaded 11 feet (mean), and a speed of 9½ knots.

The engines are triple expansion of 500 I.H.P., and bunker capacity is 63 tons, auxiliary machinery, 2 capstans, 20 tons each, and one 5 ton cargo winch. Equipment includes:—2 Fire pumps capable of discharging 40 tons per hour with 4 discharge branches on deck. All necessary lighting plant and equipment is provided and the vessel is fitted for the supply of steam through flexible hose pipes to other vessels. She also carries diving gear and a set of portable salvage pumps.

In those ports which provide salvage services several highly specialized types of craft are required. The principal of these is designated " camel " and consists of a form of " dumb " barge which is used in conjuction with other craft of the salvage service in connection with the raising of sunken vessels of limited size. (Approx. maximum weight, 2,000 tons.) They are constructed of steel and specially strengthened to withstand hard wear and immense stresses. They have rounded ends and are extensively sub-divided into watertight compartments to facilitate " lifting " operations, and are equipped with boilers to provide steam for the deck winches. The deck is elaborately fitted with very heavy bollards and the requisite fair leads in appropriate positions.

FIRE FLOATS

It is customary for the local Municipal Fire Brigades to supply the organization for dealing with all ship fires in a Port, but in the Port of Liverpool, until recently, this service was operated for all ship fires outside the docks, by the Port Authority, whose combined buoyage and salvage craft were fully equipped for the purpose. These craft acted in close co-operation with the Fire Brigades who provided an immediate nucleus of personnel and equipment, supplemental to the Port Authority's vessels, upon receipt of an emergency call, and any subsequent necessary reinforcements were transported by other craft of the Port Authority. These vessels attended Dock fires, etc., only upon request from the Fire Authorities, who now own and operate their own Dock and "Outside " Fire craft.

Fire Floats are of 2 distinct types. In large ports, for example London, Liverpool, Southampton, Bristol, situated on estuarial rivers and having long sea approaches thereto, in the form of open and exposed sea channels, it becomes necessary to provide craft

Marine Services of a Port—continued

of substantial size and construction to embody the requisite seaworthiness, in order to be able to provide fire assistance to vessels outside the immediate approaches to the port. For the purpose of operations in docks a considerably smaller and less robust type of craft is sufficient. These latter frequently take the form of conversions from other types of craft, with the addition of the necessary power equipment for the operation of fire monitors, hoses, etc.

Fig. 7 is a photo of a vessel of the former type, which embodies all the above mentioned essential specifications. She is a comparatively new steel vessel, converted from a small pleasure craft, particulars of which are:—Tonnage 62 nett, 309 gross, length 120 feet, beam 27 feet, depth 12 feet, draft 10 feet, speed 12 knots. She is divided into 7 watertight compartments and is twin screw. Propulsion is diesel electric, which is bridge controlled. The steering gear is electrically operated, main engines 2 Nominal h.p. 208, I.H.P. 1,600, main dynamos 900 KW output. 1,246 E.H.P., electric motors driving shafts 2, each 500 h.p., auxiliary engines and dynamos two 45 KW output, fuel capacity (oil) 50 tons.

Particulars of the Fire Fighting equipment are as follows:—

Fire pump—3-stage turbine pump. Capacity 3,300 G.P.M., driven by 300 h.p. electric motor.

Fire monitor—3 inch nozzle. Capacity 2,000 G.P.M.

Salvage pumping outfit—Capacity 1,000 tons per hour 4 way, 6 inch diameter inlet and outlet, suction boxes on starboard and port sides respectively.

Equipment—12 small swivelling nozzles, mounted on gunwales. Capacity 235 G.P.M. each. 8 large foam branch-pipes. Capacity 6,400 G.P.M. 4 small foam branch-pipes. Capacity 1,800 G.P.M. 2 multi-jet foam inductors, capable of supplying 8 large foam branch-pipes. 4 inline foam branch capable of supplying 4 smaller foam branch-pipes.

Included are—500 gallons of foam compound. 7,500 feet of hose, oxygen breathing apparatus, etc. 4 searchlights. Capacity 1,000 watts each. Oxygen acetylene-cutting equipment. Rocket apparatus. Revolving ships' hold branch-pipes.

Communications, etc. Marconi " Seamew " wireless installation. Home Office V.H.F. radio telephony. Echo sounder. Loud hailers.

The accommodation provides for crew forward; lounge, saloon and officers' quarters, amidships; and fire equipment is housed aft.

The following is a description of a craft of the latter type, as mentioned above, a number of which are stationed in the docks of a large port. Dimensions:—Length 52 feet, beam 13 feet, depth 3 feet 6 inch, draft 3 feet 6 inch, speed 10 knots.

She is a new wooden twin-screw craft, converted from a former motor cabin-cruiser, and is propelled by two 6-cylinder marine petrol engines, each 78 h.p.

Particulars of her Fire equipment are as follows:—

Fire pumps—4 heavy pump units, capacity 800 G.P.M. and connected to suction boxes. All delivery outlets are interconnected to the fire monitors and delivery leader boxes.

Fire monitor—" Titan," 2½ inch nozzle.

Equipment 6,500-ft. hose. Two foam branch-pipes and foam. Inline foam inductor. Revolving ships' hold branch pipes. 1 searchlight. 1 small generator for auxiliary purposes.

TUGS

Among the essential ancillary services of a Port is that of an efficient and comprehensive tug organisation.

This is a service of paramount importance in order to ensure the safety and rapid handling of vessels, and the avoidance of delay in all their movements within the Port. In certain ports all tugs working within the docks are owned and operated by the Port Authority, but in the majority of ports the various fleets of tugs are owned by different private tug companies and in a few cases by certain shipping interests. This provides healthy competition, although it is customary for a general schedule of rates to be agreed upon between the several tug owning companies, for the varying forms of towage existing in each port. The primary function of tugs is to render to vessels the necessary assistance in docking and undocking; transit through dock systems, berthing in docks and at stages, jetties, etc.; and in navigation and manoeuvring in narrow waters, for all of which services the essential attributes are power and handiness. In addition the requisite degree of seaworthiness is necessary, as they may be required to operate in abnormal conditions of weather and in open waters. Other services rendered by them include towage of various types of " dumb " craft, comprising floating cranes, grain elevators, barges, lighters, etc., within the port, and in giving towage assistance to " lame ducks," outside the port. They also carry out coastal towage in connection with vessels bound for other ports, for breaking up purposes, assisting vessels in distress after a casualty and in rendering aid in salvage and fire services, for which certain tugs are provided with a limited amount of equipment. It is notable that the general design and size of the typical modern tug for port use has not materially altered from that of years ago, when it was customary for them to cruise as far afield as the "Tuskar," from Liverpool, in search of " tows." It is probable that no type of vessel so completely fulfills the purpose for which it is

Photo courtesy of P.L.A.

Fig. 8. Typical Tug in service on River Thames.

designed as the tug, moreover it is usually handled with superb skill by those engaged in this highly specialized service, which entails a thorough knowledge of local conditions. It is remarkable how several tugs, engaged together upon the same operation, work in complete unison and appear to anticipate to an uncanny degree the instructions of the directing official.

As opposed to the generality of shipping tugs have always maintained a marked conservative design, during the last decade, and the long established features of single screws and open bridges still remain popular if not universal.

Fig. 8 is an illustration of a typical tug used in Port service. Particulars of such a craft would be roughly:—Length 95 feet, beam 25 feet, draught 13 feet, speed 12 knots, H.P. 1,100. As to methods of propulsion, controversial opinions exist. An enumeration of the various pros and cons thereon is as follows:—

Steam propulsion can transmit a fraction of, or a large proportion of, the total power developed within the vessel, through the medium of a tow rope, to the tow. It operates smoothly and without " snatch " to the tow and provides the maximum amount of reliability, manoeuvrability and towing efficiency.

It provides for instant reversing ability, and its maintenance costs are less and it probably provides longer engine " life " than other forms of propulsion. Steam also requires less highly skilled personnel for operation.

Diesel propulsion, on the other hand, is more efficient and economical as to maintenance, as it can be shut down when not required. Several such installations have been made which have proved advantageous from the economic point of view.

When the tug is pulled ahead by the tow the trailing action of the propeller causes the engine to turn ahead and makes it difficult to engage astern gear, unless special reversing gear is fitted.

Marine Services of a Port—continued

A number of tugs are equipped with Diesel-electric propulsion and these can manoeuvre and tow as readily as the steam-driven tugs. Initial cost, unfortunately, is high and the power plant complicated, requiring highly skilled personnel for its operation. It possesses, however, all the advantages of a diesel engine, without its disadvantages.

To summarize, therefore, the diesel engine offers economy in fuel and elimination of "stand by" losses, whereas steam, although less efficient (in fuel consumption), can manoeuvre and tow with greater efficiency, is more robust, reliable, easier to maintain and simpler to handle. Further, the stability of a vessel is increased by the greater weight of steam engine and boilers which ensures greater safety when heeling and when the towrope is " gogged " down.

A sound system of organisation, especially for the rapid interchange of information and instruction between disengaged tugs and their managements is essential. This is effected by the establishment of various offices in suitable positions and convenient as laybyes for tugs. Harbour tugs operate with a comparatively short length of towrope and in order to further decrease it in restricted areas it is " bowsed " down to the tug's stern by a " gob " rope. Towage alongside a vessel is adopted as a means of increasing direct power and in cases necessitating the use of several tugs. It is to be noted that in certain ports the use of tugs inside the docks is restricted to those owned by the Port Authority. Small tugs, used for the towage of barges, flats, etc., are of many and diverse types and are usually owned by the various lighterage companies.

BARGES AND LIGHTERS

An important item of a port's resources is an adequate supply of barges, lighters, etc., to facilitate the handling of cargoes by overside work, and the transport of goods between adjacent docks and wharves. Some ports are dependent to a considerable extent upon these craft, which are mostly owned by the various tug and lighterage companies engaged within the port.

The types of craft included within this category are so numerous and of such diverse forms that it is impossible to particularize them. Certain ports, by reason of their geographical location and propinquity to other ports and manufacturing and distributive centres, interconnected by rivers and canals, are essentially " barge " ports, and a large proportion of their landing of cargoes is performed by overside working, by means of barges and lighters. Of these the picturesque sailing barge, which is such a familiar, though diminishing, feature, peculiar to the London River, constitutes the aristocrat of all types of these craft. Unlike the others, this particular type of barge impinges upon, if not engages in, actual coastal trade, but is only to be found in the Thames and its estuary. Within the general classification of barges are included:—Powered, sailing and dumb barges; lighters; flats, derrick flats, canal barges and boats, sand grab craft, fuel-oiling and separation barges, etc., all of which possess their own various and individual functions towards the provision of transport and the rapid handling of the trade of a Port. The average barge has a carrying capacity of 100-150 tons and may be either self-propelled or dependent upon towage. They vary considerably in both design and dimensions and among them, may be cited, as complete contrasts—the modern steel diesel-engined craft, capable of navigating in strong tidal waters; the Thames barges propelled by sweeps, and those ancient wooden craft, the origin of which dates back to their primary service as brigs, barques, etc., prior to their conversion to coal and other bulk commodity-carrying craft.

Lighters are an " open " type of barge, principally confined to service in docks. They are both powered and dumb—usually the latter. The principal distinctive difference between barges and lighters is the flat sloping (" swim ") ends of the latter.

Flats are smaller than the above, and are both self-propelled and dumb. Derrick flats, of approximately the same capacities, assist with their own gear and equipment in the handling of overside cargoes and are almost universally powered.

Fuel barges are required for the refuelling of small vessels and the " topping up " of larger vessels in the rivers, etc., of Ports. They are of the largest steel lighter type, and self-propelled.

The oil separator barge is a similar specialized type of craft, equipped for the removal and purifying of fouled oil from vessels. All the above types of craft are mostly owned by the various barge and lighterage, etc., firms operating within the port and in certain cases by large manufacturing and shipping firms, which are regular exporters of their own particular commodities through the Port.

FERRY BOATS

Although not strictly included within the marine services of a Port, these craft contribute, and to a considerable degree, to the general efficiency of a port, by their regular services in transporting the necessary persons who are engaged in the work of the Port. These types of vessels differ considerably in design and size, and also in the nature of the traffic for which they operate. These variations include comparatively large craft for the accommodation of vehicular traffic and those exclusively confined to the transportation of passengers.

In the Port of Liverpool and Port of London ferry services of both kinds exist and indeed at most ports situated on both sides of a river or estuary.

PUBLICITY VESSELS

Before concluding the list of services, there remains one which is provided by certain of the largest Ports under the term " Publicity." In these cases it is customary to commission, during certain seasons, a vessel suitable for providing entertainment and sightseeing facilities for clients of the Port Authority, for example merchants, shippers and civic officials, Dominion and foreign visitors, etc. These vessels are also available for occasional visits to the Port, of " Distinguished Personages." In certain large ports, however, it is customary, as an advertising medium, to maintain special craft for these purposes, and the Port of Liverpool owns and uses a vessel originally designed for the above services, in combination with surveying, buoyage, etc., but later converted for the former duties only. She is a twin-screw, coal-burning vessel, particulars of which are:—Length 185 feet, beam 35 feet, draught 11 feet, speed 12 knots. Her equipment includes radar, wireless telegraphy and radio telephony.

She carries 80 passengers, and provides seating accommodation in the saloon for 42 persons. A smoke room and 10 single cabins, with appropriate toilet facilities, etc., also make her suitable for periodical inspections of lighthouses, lightships, revetments, etc., by the Committee and officials of the Port Authority.

In concluding these notes it may be said that the marine services of a port, with their various types of craft, are in partnership with " They that go down to the sea in ships and do business in great waters." Their—the former's business, may be neither in ships—as the term is usually interpreted—or in great waters, as expressive of deep sea service, but nevertheless the two services are indivisible and interdependent with one another as in the absence of one of them, the others would become incapable of survival.

The Port of Bristol

The 16 m.m. sound and colour film with a running time of 45 minutes has been produced in Bristol by Messrs. F. G. Warne, Ltd. It will be distributed throughout the U.K. and overseas, and copies are also available for loan to shipping, commercial and industrial interests in the United Kingdom.

The object of the film is to publicise the facilities and services offered by the Port of Bristol (City, Avonmouth and Portishead Docks) for the quick turn-round of shipping and the efficient handling of imports and exports. Shots were taken at the City and Avonmouth Docks. At the former the operations featured are the handling of Woodpulp, Esparto Grass, Timber, Wines and Stout. At the Avonmouth Docks the principal commodities featured are Grain, Refrigerated Produce, Petroleum, Tobacco, Bananas, Timber and General Goods and the loading of export cargoes.

Also illustrated are some of the mechanical equipment in everyday use in the port, with shots of cranes, grain elevators, fork-lift trucks, powered runabout trucks, shunting engines and tractors, portable conveyors and timber carriers.

Winter Navigation on the St. Lawrence

A Suggested Method of Overcoming the Limitations due to Ice

By J. G. G. KERRY, M.E.I.C.

(concluded from page 225)

FOREWORD

In this instalment Mr. Kerry discusses the sections of the waterway from the Saguenay River to Lake Ontario, the probable effect of the proposed Dams and Barrages and deep water channel upon the movement of ice and its dissipation by the warm water currents from the Lakes, together with the economic benefits which would result therefrom.

THE ESTUARY OF THE ST. LAWRENCE RIVER

ESTUARY LIMITS.

The Estuary proper may be described as extending upstream from the mouth of the Saguenay River to a point a few miles west of Ile aux Coudres and the general character of this somewhat difficult section is shown by the map (Fig. 5, page 251). The limits of the Estuary are fixed by the change in the character of its waters which at the west end are almost fresh and in summer, warm, and when opposite the mouth of the Saguenay River are definitely cold and saline. The Estuary is in fact the mixing pot for the fresh waters of the river and the salt waters of the Gulf. This section of the valley is marked by very large shoal areas, narrow steamer channels, except along the north shores and many changing and conflicting tidal currents. It naturally becomes a gathering-place for drifting ice at the beginning of the winter and its channels are soon made dangerous or impossible to the passage of vessels. Winter navigation in the Gulf makes its western terminal at Pointe aux Pic which is well east of the shoal area.

PROBABLE EFFECT OF BARRAGE AT ISLE AUX COUDRES.

To overcome these difficulties it is suggested that the upstream movements of the tides should be definitely stopped by the construction of a dam or barrage extending across the Coudres Channel and thence south-east across the shoals to the neighbourhood of Iroquois Point on the south shore, a difficult undertaking but probably not more formidable than the works built by Netherlanders in closing off the Zuyder Zee from the Ocean. Above the barrage the level of the water could be held close to that now marked by high tide. In the Estuary, as it would then be, there would be below the barrage a powerful flow of fresh and relatively warm water coming through the sluices in the barrage and probably flowing close to the north shore. This current would ride on top of the salter waters of the Estuary as in fact the upriver waters do to-day, but in a more compact and powerful stream that would make the distinctive character of its waters capable of being detected for considerably greater distances. No ice would be allowed to cross the barrage and it is doubtful if any would be met with in the ship channel for the full length of the Estuary. The cutting off of the tidal flow would certainly help to simplify the current patterns over the whole length of the Estuary. The conclusion then is that extensive engineering constructions are necessary to make the Estuary navigable at all seasons of the year, but the constructions required are by no means without precedent and they would fairly well solve the ice problem between Quebec and the mouth of the Saguenay River.

THE QUEBEC SECTION

PROPOSED DIVERSION DAMS.

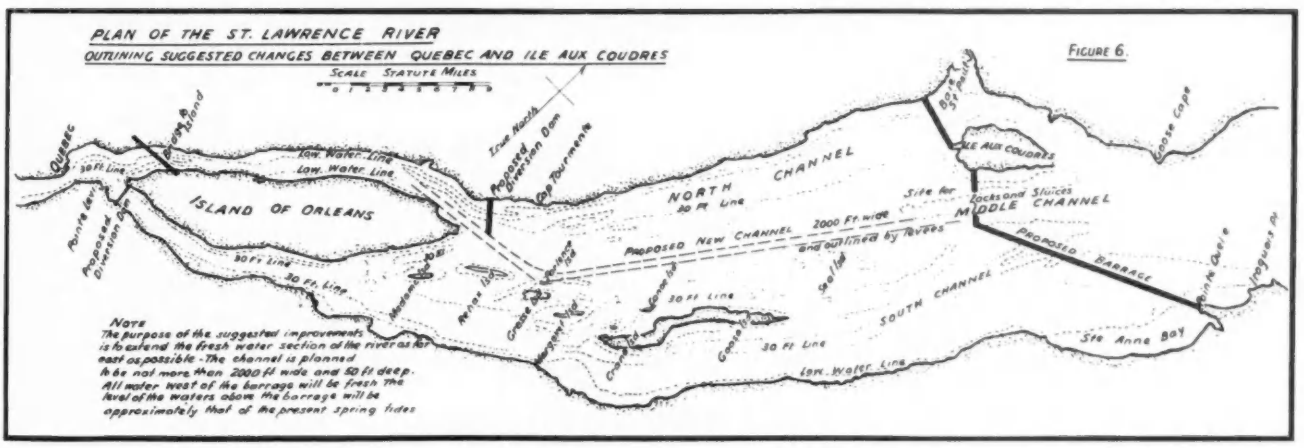
A study of Fig. 6, which is a map of the river area between Quebec and Ile aux Coudres, will show that it is proposed to cut off the present channel south of the Island of Orleans making all the area from the diversion dam as marked on the map down to the proposed barrage into a fresh water lake. This lake would freeze over solidly early in the winter. It is also proposed to pass the whole discharge of the St. Lawrence River down the present channel north of the Island of Orleans and through a new channel of definitely limited length and breadth across the present shoal areas down to the barrage, the purpose of these works being to extend a fresh water and ice free channel from Quebec eastward as far as Ile aux Coudres and to keep the depth of the waters in the Montreal Ship Channel all year round close to 50-ft.

THE FRESH WATER RIVER

The barrage near Ile aux Coudres would become the eastern end of the fresh water section of the river which should be regarded as extending to the vicinity of the Duck Islands in Lake Ontario. These islands can be described as being on the shore line of the true deep water lake and a sharply defined entrance from the lake to the river should be created in their vicinity for use in the winter months.

TEMPERATURE OF THE GREAT LAKES.

Lake Ontario water is " warm " all winter long as it never freezes over the main lake. Experiments made in Lake Michigan under the auspices of the University of Chicago by Professor Church over a period covering three consecutive winters show that in Lake Michigan the waters have a uniform temperature from top to bottom from the end of December to the end of April, the temperature being about 40° Fahr. on January 1st and gradually falling off to a minimum of 33° or 34° Fahr. around March 15th.


PLAN OF THE ST. LAWRENCE RIVER
OUTLINING SUGGESTED CHANGES BETWEEN QUEBEC AND ILE AUX COUDRES
SCALE STATUTE MILES
FIGURE 6.
QUEBEC
ISLAND OF ORLEANS
Low Water Line
30 Ft Line
Proposed Diversion Dam
True North
NORTH CHANNEL
MIDDLE CHANNEL
SOUTH CHANNEL
PROPOSED NEW CHANNEL 2000 Ft. wide and outlined by Buoys
PROPOSED BARRAGE
Site for Locks and Sluices
ILE AUX COUDRES
Goose Cape
Ste Anne Bay
Note
The purpose of the suggested improvements is to extend the fresh water section of the river as far east as possible - The channel is planned to be not more than 2000 ft wide and 50 ft deep. All water west of the barrage will be fresh the level of the waters above the barrage will be approximately that of the present spring tides

Winter Navigation on the St. Lawrence—continued

Comparison of simultaneous surface temperatures taken by Professor Church and by Mr. Millar, of the Dominion Meteorological Observatory in Lake Ontario lead to the conclusion that the temperatures of the waters of the two Great Lakes must be very much alike at all times. Probably no serious error will be made by assuming that the temperature of the waters of Lake Ontario is about 40° Fahr on January 1st and falls off very gradually to a minimum of about 34° Fahr. on March 15th as is the case in Lake Michigan. Lake Ontario therefore may be regarded as a bowl of "warm" water to be made use of as may be desired and as can be contrived.

WARM WATER CHANNEL.

If the waters from such a bowl be poured into a trough on a cold winter's day it will depend upon the design of the trough whether the water freezes as it flows down or runs out unfrozen at the lower end of the trough. The conservation of the heat contained in the waters as they leave Lake Ontario should therefore be the first principle to be observed in designing improvements to the channel of the fresh water section of the St. Lawrence River. Professor Church's experiments furnish good evidence of the rate or rates at which a body of water with a free surface will waste its contained heat energy and it is notable that this rate of loss falls off rapidly after February 15th, a fact of first importance which makes it possible for the cooler waters of Lake Ontario in March to flow without freezing to great distances.

Theoretically the channel of the river to remain free from ice must be deep, for the water mass needs to carry a great store of heat energy with it, it must be narrow because all important heat losses are made from the surface area of the water and it must have a slope such that the waters will run swiftly and will reduce the time during which heat losses are being made down to a minimum. Working with constants based on Professor Church's experiments it would appear that a channel with a width of from 1,250 to 1,500-ft., a depth of from 60 to 50-ft. and a current speed of 3 miles per hour would be able to carry all the St. Lawrence waters without freezing from Lake Ontario to Ile aux Coudres. Further studies of the temperature cycle of the waters of Lake Ontario and the St. Lawrence River along the lines developed by Professor Church are very desirable.

CURRENTS IN LAKE ONTARIO.

The accompanying map (Fig. 7) shows the shore line of the eastern end of Lake Ontario and the depth contours in that vicinity. There is known to be a great current moving anti-clockwise around Lake Ontario but little is known either of the strength or of the constancy of this current which has never been studied. It seems desirable that the channel of a regimented St. Lawrence River should draw its waters directly from the deep section of the lake and out of this cyclonic current. A glance at the map will show that the present main entrance to the river is located more than 20 miles away from the 200-ft. depth contour and is separated from it by a great area of nearly stagnant water confined between a reef that runs from Point Edward along a string of islands to the American shore and the shore line of the east end of the lake and of the great islands that lie in it. This area is from a heat standpoint quite shallow and in slow passage across it the water of the river now gives up a very large proportion of the heat energy which it held when in the lake just west of the reef.

PROPOSED GUIDE BANKS AND DAMS.

An ice-free river will be difficult to maintain unless a suitable winter channel can be created for the river between Main Duck Island and Cape St. Vincent. This will involve the building of parrellel guide banks quite close together with a channel section of say 800-ft. wide and 100 or more feet deep, all other outlets to the lake being closed in winter. As an ice-free channel for the waters of the St. Lawrence River will be about 400 miles long and only about a quarter of a mile wide, it is desirable to consider what changes are necessary to the existing channels to make the new channel or trough effective. It will be appreciated that danger to shipping will be reduced to a minimum by the construction of the proposed channel as this will be straight, relatively wide and its waters will run at an even and constant speed. The operators at the four dams, Barnhart's Island, Beauharnois, Montreal and Ile aux Coudres will at all times have control of the flow of the river and will be able to regulate its volumes and velocities.

Between Cape St. Vincent and Barnhart's Island a distance of about 100 miles the river runs in a deep channel or channels which are far too wide for the maintenance of the desired velocity of flow and it will require to be regimented by the building of extensive guide banks and jetties. Assuming the dam at Barnhart's Island to be completed, the present depth is everywhere 60-ft. or better save for some odd jobs of cleaning up and for a 5-mile cut that must be made through the reef that crosses the river at the Galops Rapids. This cut will involve heavy work but it could not be much better placed as a source of supply for the materials that are necessary to the construction of the needed guide banks between Main Duck Island and Barnhart's Island.

BEAUHARNOIS HYDRO-ELECTRIC STATION.

From Cornwall to the Lachine Rapids, a distance of about 65 miles, the river flows through alluvial country and the channel might be briefly described as consisting of Lake St. Francis, the head race to the Beauharnois Hydro-Electric power development and Lake St. Louis, all in easily-dredged material save for the west end of the Beauharnois head race where a submerged rock reef of great width will be encountered.

Re-location of this west end with the aid of geo-physical surveys may be possible and is worthy of consideration. The level of Lake St. Francis is now under control by dams built across its eastern outlets.

Across Lake St. Francis, a length of some 35 miles in all, the channel needs but little cleaning up to give a depth of 50-ft. for at least 15 miles. What this section will particularly need is the construction of parallel levees to be built out of dredgings and to be used for the specific purpose of cutting off the back waters from the channel and for holding any ice formed in the back waters in place until it is melted away by the spring suns. All backwater and shore line ice must be rigidly excluded from the channel. Across another 12 miles of Lake St. Francis the present channel has depths varying from 30 to 50-ft. and is easily deepened and in the remainder of the channel its present depth is rarely less than 20-ft.

The Beauharnois head race can be readily deepened except at the west end as already noted and there some expensive excavation may be found to be necessary. The total length of the head race is about 15 miles.

Across Lake St. Louis present channel depths in a total length of 15 miles are above 50-ft. for 3 miles, between 35 and 45-ft. for another 5 miles and there is an average depth of about 30-ft. for the remaining 7 miles. Levee protection will be necessary here as in the case of Lake St. Francis.

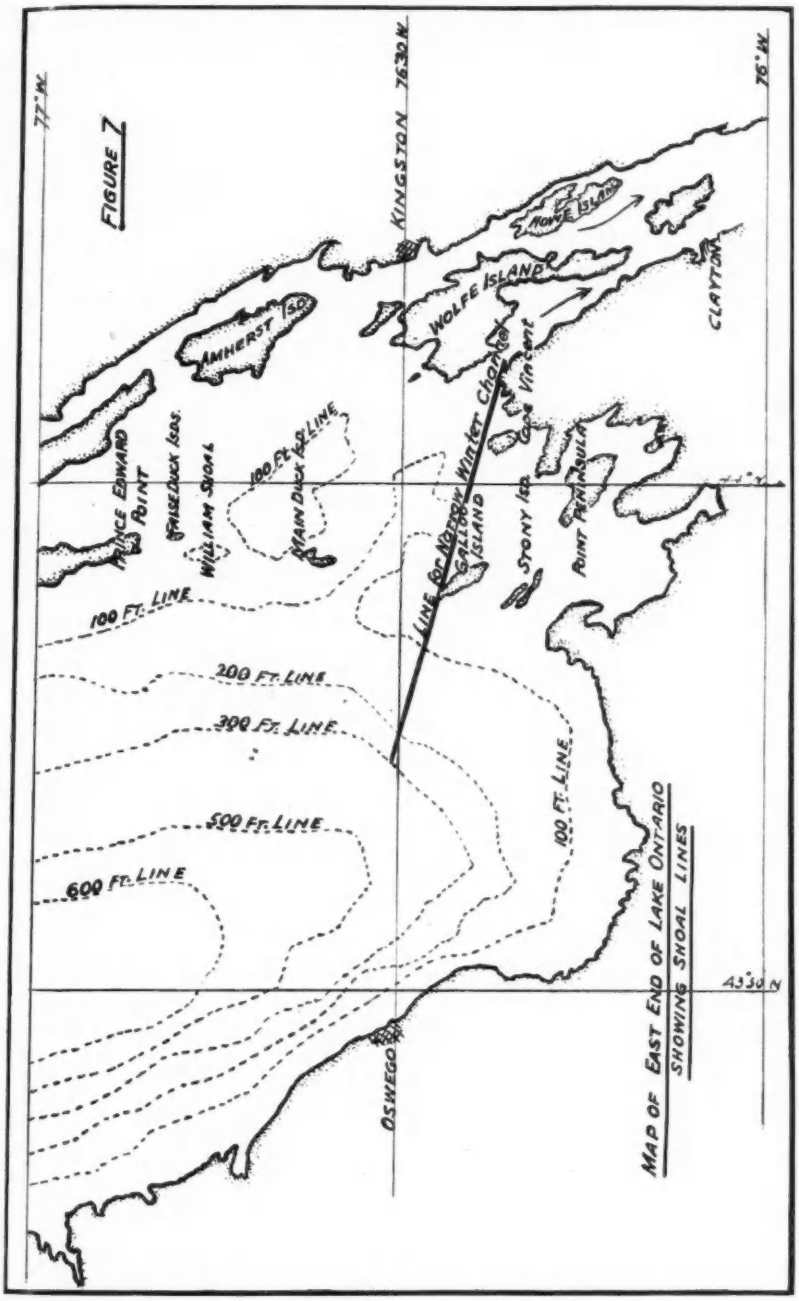
MONTREAL HARBOUR COMMISSION DREDGING.

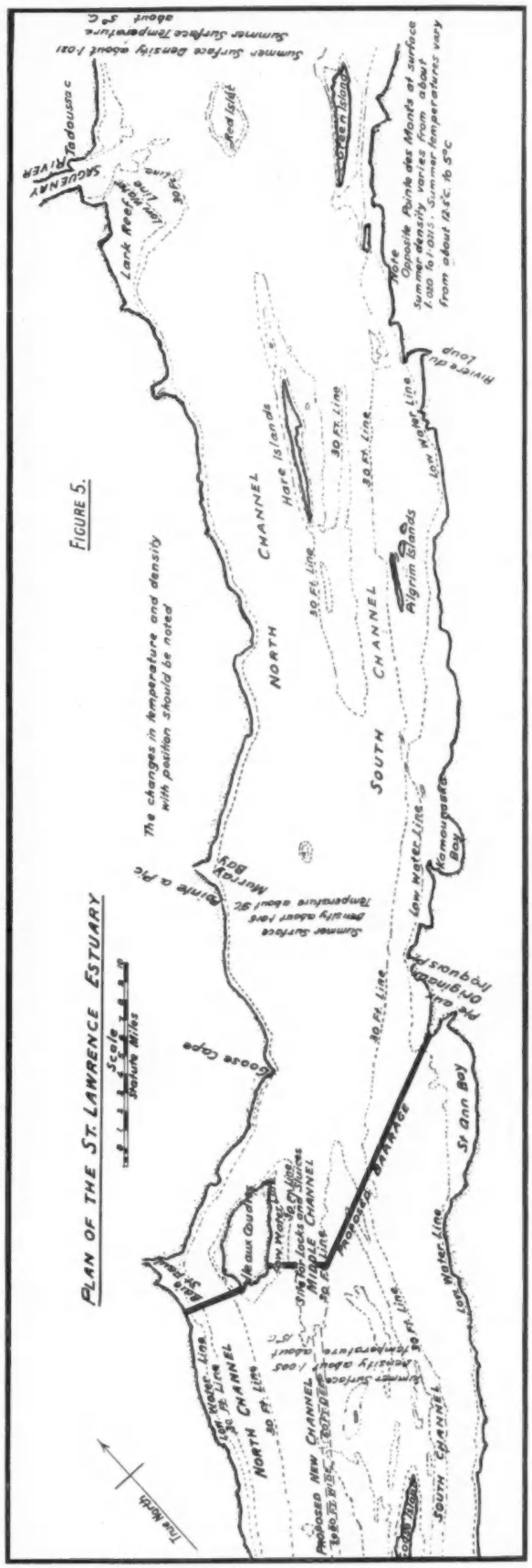
In the present Lachine Rapids after the proposed power dam at Montreal has been built a depth of from 25 to 35-ft. will prevail for about 4 miles and the bottom material will be hard, but no harder than that out of which the west end of the Montreal Harbour was dug. Some 60 years ago the writer watched the dredges of the Montreal Harbour Commission cutting down to a total depth of 50-ft. for the foundations of the Canadian Pacific Railway bridge across these rapids and in the quiet waters that will be created by the proposed Montreal dam, the task of dredging can be carried on much more advantageously than was the work around the Canadian Pacific Railway bridge.

Below the Lachine Rapids no trouble need be encountered either in obtaining width or depth until Montreal Harbour is reached.

Below Montreal Harbour and down to Three Rivers a distance of about 75 miles the present Ship Channel is being dredged to 35-ft. at extreme low water which means a depth of nearly 50-ft. under spring flow conditions. The suggested barrage at Ile aux Coudres can be made to hold the waters over this section closely up to spring level during the entire year and to complete the final 50-ft. channel only widening will be necessary. The present channel varies from 500-ft. in width to 1,000 ft. on curves. Levee protection as in the case of Lake St. Francis will be necessary all the way from Montreal Harbour to Three Rivers.

Winter Navigation on the St. Lawrence—continued





CHANNEL REGULATION—THREE RIVERS TO QUEBEC.

Between Three Rivers and the Quebec Bridge, a distance of about 72 miles, the river flows generally in a gorge in the bottom of which channel dredging has been done where necessary. Dredging in fact has been necessary nearly everywhere from Three Rivers to Grondines, a distance of some 32 miles. Below Grondines but little of the channel length has called for dredging. Down this length of 72 miles the proposed barrage at Ile aux Coudres will hold the water level up to heights coinciding closely with the high tide marks made during periods of high discharge from the upper river and throughout this channel will need no deepening—only widening. The present channel width is 550-ft. Throughout this section the river is very wide at high water and its regimentation accordingly difficult. Down as far as Grondines the heavy dredging will provide material for the construction of the necessary protecting levees. Below Grondines the construction of a series of jetties to narrow the channel to desired width will be desirable especially as such jetties will give an anchorage to the local ice

Winter Navigation on the St. Lawrence—continued

and convert it into what the oceanographer describes as fast ice, ice that remains in place throughout the winter. With the disappearance of the tidal fluctuations and the cutting off of any great currents between the jetties, the side ice in this section will have but a small tendency to work out into the channel and should melt away in place. It should be noted that success in regimenting the river from Montreal to Ile aux Coudres will depend upon the establishment of a joint control of the flow of the St. Lawrence and Ottawa Rivers, the discharge of the St. Lawrence River being reduced at the outlet of Lake Ontario whenever the Ottawa River is in flood. By this arrangement variation in the flow of the river below Montreal can be reduced to a minimum and the regimentation of the 200 odd miles of river between Montreal and Ile aux Coudres made relatively easy.

CONCLUSION

It will be seen from this preliminary study that Canada can, without being called on to face tasks, the like of which she has not already encountered, create for herself a 50-ft. channel from the Gulf of St. Lawrence to Lake Ontario and that in so doing she will go a very long way towards releasing the ice fetters that have always hampered the commerce of her St. Lawrence ports. She might perhaps be able to overcome this difficulty in a practical sense completely.

Objection will be taken to the effect that an open channel in winter does not mean open ports or accessible harbours. The answer is that traffic by rail and traffic by air go merrily on in Canada all winter long and it is just as easy to protect wharves and harbour basins by shed coverings as it is to protect freight terminals on railways or to provide shelter for large aircraft. Only no one has ever attempted so far to develop that simple solution for the benefit of shipping.

The programme outlined in the foregoing article is a programme that should not be undertaken without very thorough preliminary study nor carried out by any other than a step by step process, each new difficulty that might arise being disposed of before the next step forward is made. The ultimate possibilities however should never be lost sight of.

It is however important to realise that ice is not an Act of God in the face of which no protective measures can be taken. Ice is an engineering substance, the processes for manufacturing which, and for its destruction, are well known. It only remains to study its appearances in navigable channels closely and to ascertain whether means to prevent these appearances in defined areas are available.

The works to be built will be very large and expensive, but the possibilities of success are sufficiently promising to warrant most careful preliminary study and the preparation of provisional plans and reliable estimates.

This paper has purposely been written so far as possible in simple language, free of technicalities and no reference has been made to the work of the many able officials and scientists whose researches have made the writing of the paper possible. To them is owing any credit that may arise out of the creation of a great vision.

The St. Lawrence Seaway

Ministers Stress Need for Action

With reference to the article on the "St. Lawrence Seaway" which appeared in the November issue of this Journal, some further pronouncements on this important subject have recently been made in the U.S.A., and in Canada, and the following salient points will be of interest.

In the first place, Mr. Truman, President of the United States, has addressed a letter to the Chairman of the Executive Committee of the Great Lakes-St. Lawrence Association, which was read at the recent annual meeting of the Board of Directors in Washington. In his message, Mr. Truman urgently calls for the execution of the St. Lawrence Seaway and Power project as a vital feature of the new national defence programme of the U.S.A. The text of the letter, reproduced in full, is as follows:—

"I am glad to know that the Great Lakes-St. Lawrence Association is continuing its active interest in the St. Lawrence seaway and power project.

"In this time of national danger our country must increase its strength as part of the common defense of the free world against communist imperialism. This requires us to enlarge our armed forces and increase our current output of defense equipment and supplies.

"At the same time we must continue to increase the basic productive power of our economy. We must be prepared for a period of international tension that may last for many years. It should be our aim, therefore, to increase our economic strength in the months and years ahead in every possible way for economic strength underlies our own continuing defense efforts and those of other free countries.

"It has been clear for a long time that the St. Lawrence project will make a major contribution to our growing economic strength, through providing both a new source of low-cost power and a new avenue of low-cost transportation. The demands of the present situation greatly increase the urgency of getting started on the St. Lawrence project and completing it as rapidly as is physically practicable.

"We urgently need the seaway, especially as a secure route for transporting iron ore from new sources to supplement our diminishing domestic sources of ore. We urgently need the power, not only for normal use in farms and homes and factories, but especially to help in expanding important chemical and metals industries. I am convinced that the relatively small investment of materials and manpower required to build the St. Lawrence project will be richly productive. I hope that your Association will continue its efforts to bring about widest possible public support for the St. Lawrence seaway and power project."

Secondly, the Minister of Transport of the Canadian Government has taken a very strong stand in the matter of the Seaway and Power Project. He is reported in a recent issue of "Shipping Register and Shipbuilder"—a Canadian monthly journal—as having stated that something must be done about the project very soon, and that many Canadians were getting impatient at the delay.

The Minister said that if no progress could be made on the combined scheme of navigation and power development, as outlined in the treaty signed by Canada and the United States in 1941, as would unfortunately seem to be the case, the application for power development by the Province of Ontario and the State of New York should be referred to the International Joint Commission for consideration and that "Canada should explore the possibility of constructing a deep waterway on the Canadian side of the boundary." The Minister went on to say "I believe that now is the time for action on the St. Lawrence Waterway, and that the time has arrived for plain speaking thereon. There is every reason for proceeding with this project now. From the military, economic and strategic viewpoints, the combined development of navigation and power on the St. Lawrence should be carried out at once and should no longer be delayed. It is inconceivable that lake carriers should continue to be bottled up in the Great Lakes and not be able to come down to Montreal because of a short series of 14-ft. draft canals. It is inconceivable likewise that iron ore in urgent demand in the Great Lakes area should be blocked from moving westward for the some reason. It is no less inconceivable that water power urgently required for military and industrial purposes, both by the Province of Ontario and the State of New York, should go to visitors."

In conclusion, Mr. Chevrier said: "The people of Canada want this development. The Government of the United States has declared itself in favour of it on many occasions. But we cannot sit idly by and wait forever. If the Congress of the United States does not want to take action, we should know. If there are interests in the United States that are going to stand in the way of development forever, Canadians ought to be told."

Water Sampling in Estuarial Waters

Some Simple Devices for use in Port and Haven Surveys*

By J. N. CARRUTHERS, D.Sc., F.Inst.P. †; H. G. STUBBINGS, M.A., Ph.D., B.Sc. ‡
and Commander A. L. LAWFORD, R.N. (ret'd) †

INTRODUCTION

MODERN investigations undertaken for the betterment of harbours and their approach channels necessarily include researches upon silt content, upon water temperature, and upon other characteristics of the water such as salinity. Where detailed attention has to be devoted to the water conditions in an estuary, it is necessary to carry out researches good for all depths and for all states of tide. For one thing, there is characteristically a landwards creep of saline water at the river bottom; then, too, the silt burden of the water will often vary with depth, and (for a given depth) with the state of the tide, moreover, the landwards reach of salt water will be a function of tidal state.

The expert commissioned to carry out the essential investigations upon water conditions will have at his disposal the fine instruments developed over many years by his oceanographer colleagues. With, perhaps, one exception, he will not be at a loss for instruments so far as availability is concerned; that exception is the subject of this present paper.

It is contended, however, that one real difficulty over instruments confronts him. Whereas he, to observe continuously at one point, can employ existing instruments, it is not practicable to multiply observations, if this involves supplying helpers, detailed to operate contemporaneously from a number of small boats, with instruments which, besides being highly expensive, are too good for certain simple needs and would be placed at risk in the hands of inexpert people.

It is proposed to give below a description of certain rather crude apparatus which could be cheaply "home-made" in quantity, and which, it is believed, could serve to let sampling be done from small boats at many places, whilst the experts were busy with superior work from their launch.

The use of the samplers to be described is not, of course, limited to the particular purpose here in question; they could equally serve the needs of any impecunious amateur oceanographer who, wishing to investigate sub-surface conditions in the sea, lacked the means to purchase any of the expensive instruments which are available—providing that he had some modest aptitude with simple tools.

There is a certain serious difficulty which faces the man whose job it is to carry out investigations on water conditions and silt burden in an estuary where strong water movements prevail. He cannot possibly scout the need to take samples at different depth intervals throughout the water column, and he must know from what precise depths his samples come. If he can tolerate weight, and can handle "gadgets" (as no doubt he could from a sizeable launch), he can use some form of depth indicator recording pressure, or can pump air down a pipe having an open end at the sampling depth. This latter practice, which has often enough been followed, merely requires that he note the maximum pressure registered by a manometer or other device, but the method is cumbersome.

It may be necessary to use samplers of heavy weight fitted with fish leads to achieve acceptable correspondence between line out and depth reached, but that is hardly tolerable in the case of small boats. Probably as good a practice as any would be to follow the tried method of observing used by the Port of Bristol Authority which is described later.

Although the primary purpose of these samplers is for use in port and haven surveys, they can obviously be applied to researches on pollution of rivers and lakes. In addition to their suitability for amateur oceanographers, they are readily adaptable to such everyday uses as the taking of samples at varying depths in swimming pools.

PART I—OPEN-CLOSED SAMPLERS

The two samplers to be first described have, for convenience, been called respectively the "Emsworth" and the "Havant" water samplers. They were verbally described by the present authors before a meeting of the Hydrographical Committee of the International Council for the Exploration of the Sea at Edinburgh in October, 1949. At the lecture then given, films were shown demonstrating the working of the two "home-made" instruments under water, and the thanks of the authors are here expressed to the responsible authorities of H.M.S. "Vernon" for use of their tank and other necessary facilities.

The "Emsworth" sampler was designed for use when a record of temperature is wanted in addition to a sample of water. The idea was to avoid the need for using the expensive Knudsen insulated bottle. This latter, costing from £80 to £100 without its special thermometer, is much too good for the quality of sampling usually required in surveys of the type here in question.

Admittedly, this crude sampler requires a thermometer which is seriously expensive, but the provision of such is hardly to be avoided. A much cheaper alternative would be to use a thermometer whose bulb is encased in hard rubber or other insulating material. Such thermometers are customarily used for getting sea-bottom temperatures at certain lightships, but they would not be practicable in a river survey because they require a long wait to take up the temperature of the water.

Actually, the thermometer used with our simple "Emsworth" sampler is of the deep-sea reversing type. Such thermometers are left down for a few minutes at the desired sampling depth, and are then turned upside down by means of a messenger slid down the suspension. This results in the breakage of the mercury thread, as happens with an ordinary clinical thermometer. When the thermometer is brought back abroad the observing boat, the temperature at which it was somersaulted can be read off against a scale now the right way up, but which was upside down during descent.

The simple but effective "Havant" sampler can be used to some advantage where interest attaches to observing the so-called "discontinuity layers," i.e. when it is desired to find in how thin a layer notable changes in water conditions take place. The problem of depth finding exists, of course, and it is desirable to leave this apparatus down open for some minutes to ensure that it flushes out at the wanted depth, and brings up a sample representative of that depth only.

In the case of the two original samplers already tried and described below, the cylinders were of metal tubing, but it would be no trouble at all to use plastic tubing or cylinders of glazed earthenware if so preferred by the analyst who would later examine the water samples collected.

THE "EMSWORTH" WATER SAMPLER

The Frame.

The general form of the sampler is readily discernible from the diagram (Fig. 1) and the photographs (Fig. 3). The framework of the apparatus is formed from two pieces of wood, a straight piece 32-in. × 2-in. × 1½-in., to which is screwed a side piece specially shaped to receive the cylindrical sample container. At each end of the main frame two holes are bored. At the upper end is a hole through which passes at ¼-in. bolt acting as a pivot for the upper closing lever, and below this a rather larger hole

*This paper is published with the approval of the Lords Commissioners of the Admiralty, but the responsibility for any statements of fact or opinions expressed rests solely with the authors.

†Hydrographic Department of the Admiralty.

‡Admiralty Central Metallurgical Laboratory.

Water Sampling in Estuarial Waters—continued

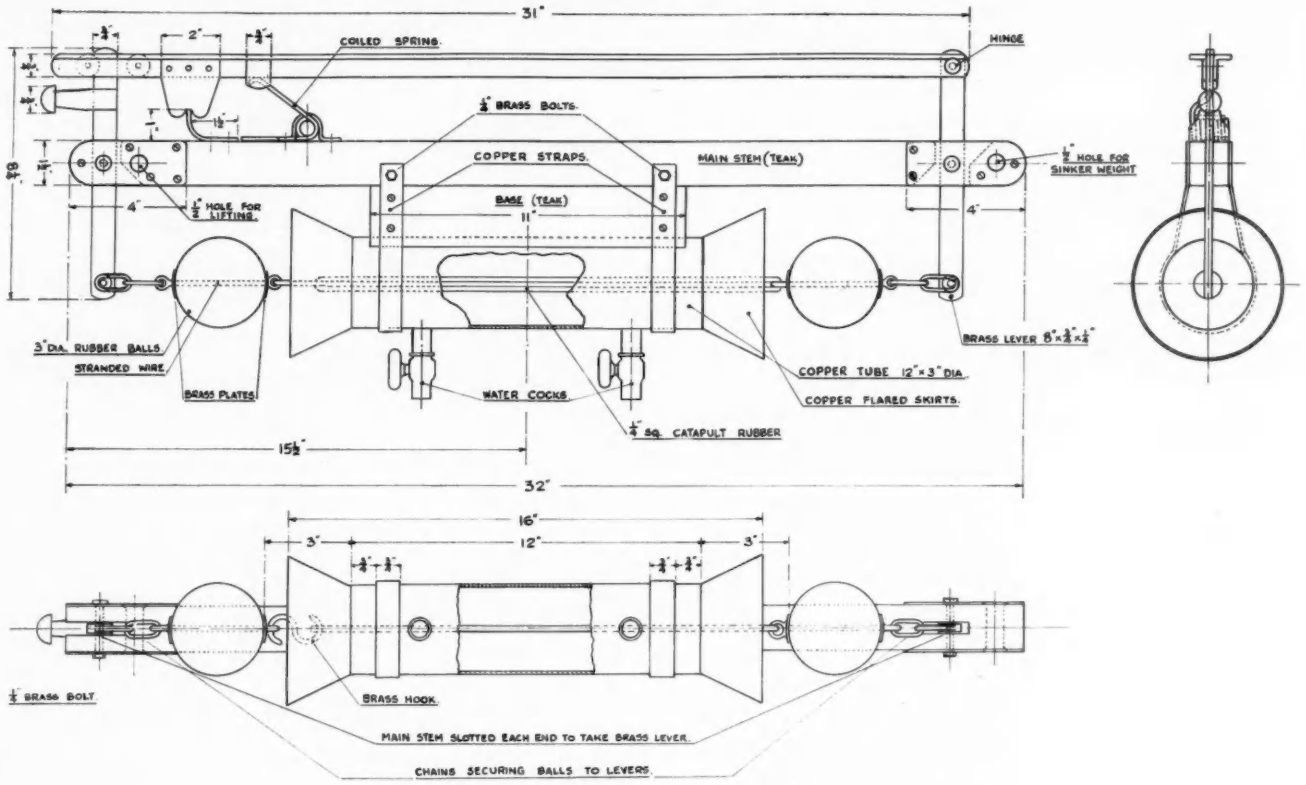


Fig. 1. " Emsworth " Water Sampler.

through which is passed the 1½-in. rope by which the apparatus is lowered. For convenience in operation it is desirable to have the lever pivot near the end of the frame and the hole for the rope below this and not in the reverse position. At the lower end of the frame there is a similar hole for the bolt of the shackle carrying the weight. A little above it is a smaller hole for the pivot of the lower closing lever. To prevent damage to the weakened ends of the frame these are protected by suitably drilled brass plates screwed to the frame.

The Sample Tube.

The sampler proper consists of a short length (about 12-in.) of 3-in. diameter copper tubing with ⅛-in. thick walls, fastened to the shaped wooden portion of the frame by two thin copper straps and wood-screws. Flared copper flanges are brazed to either end of the copper tube, making the total length of tube about 16-in and the diameter of the flared ends approximately 5½-in. These flanges serve to increase the flow of water through the apparatus as it is lowered in the " open " position and also to ensure that the rubber balls snap back into the ends of the tube when the apparatus is " closed." The upper flange is perforated several times near the point of union with the tube, so as to allow water to drain out of the upper flared cup when the apparatus is hauled out of the water.

Stopcocks are provided at the upper and lower ends of the sampler. These are readily formed from short lengths of narrow copper tubing (7/16th-in. bore) brazed to the wide tube, into which common gas-cocks are tapped or brazed. The upper cock serves to admit air to the sampler and so facilitate withdrawal of the water sample through the lower cock. For greater convenience in bottling the sample, and as a further refinement, the lower stopcock may be may with a knee-joint so that the spout of the cock is directed obliquely downwards.

The ends of the wide tube are closed by 3-in. diameter rubber balls. Solid sponge-rubber children's playballs are used in the model illustrated. If a more elaborate article is required, wood or metal balls with a coating of sponge-rubber about ¼-in. thick can be used. To improve the seating of the balls in the tube ends, copper rings are sprung into the end of the tube and riveted. These rings are bevelled slightly, to increase the area of contact between the ball and the tube end and make the seal more secure. Small irregularities in the tube ends are compensated for by the elasticity of the rubber balls.

A steel wire is passed through each ball and the ends formed into loops close to the surface of the ball. To prevent the wire being pulled inside the ball small circular brass plates are soldered to the ends of the wire between the loops and the surface of the balls. Each ball is attached through one of these loops by a short length of brass chain to an operating lever at top or bottom of the frame. The two balls are connected together by a stout elastic belt attached to the loops on the other ends of the perforating wires and running through the centre of the wide tube. One end of the rubber is passed through the loop on one ball and the ends of the rubber are joined to form a continuous loop of elastic. The loop is then drawn through the sampling tube by means of a stout hooked wire and attached by a hook to the wire loop on the inner side of the other ball. The elastic belt must be of such a length, shorter than the copper tube, that the balls are held tightly in the ends of the tube when the apparatus is closed. The belt can readily be replaced if it breaks.

The Closing Mechanism.

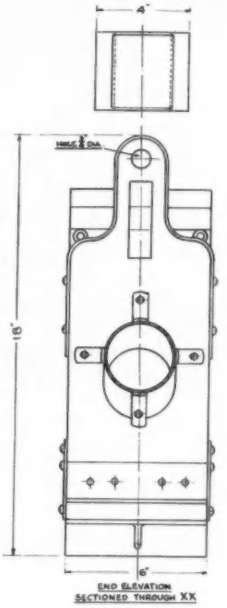
The closing mechanism consists of an upper and lower lever pivoted on bolts through the ends of the frame and attached to the rubber balls, and a long bar—the connecting bar—linking the two levers by the ends not attached to the balls and situated on the side of the frame opposite to the sampling tube. The two levers of ¼-in. brass, 8-in. long by ¾-in. wide, are pivoted so that the longer arms to which the balls are attached project over the long axis of the sampling tube.

To the shorter arm of the lower lever is hinged the long connecting bar of T-section. This can be made from two strips cut from ⅛-in. sheet brass and bolted together. To the free upper end of this T-bar is riveted a smaller piece with ¼-in. thick spacing

Water Sampling in Estuarial Waters—continued

pieces so as to form a ¼-in. broad slot, wide enough to receive the short end of the upper lever. A shallow groove is cut in the upper edge of this lever forming a notch in which rests the upper spacing piece on the connecting bar. When the short arm of the upper lever is fitted into this slot, it is held firmly by the tension on the rubber belt until the closing mechanism is released. With the upper lever and connecting bar thus engaged, the balls are drawn out of the end of the sampling tube about 3-in., against the pull of the stretched elastic belt, as in Fig. 3a. The lower lever automatically takes up the required position when the connecting bar and upper lever are engaged. As long as the T-shaped bar remains engaged with the upper lever, this tension is maintained and the apparatus remains in the " open " position. As so far described the quadrilateral formed by the upper and lower levers, connecting bar and the ball assembly is free to move about the lever pivots and take up a position with one ball further withdrawn from the tube than the other. To prevent this, a brass plate, bent through a right-angle, is screwed to the frame to form a catch. When this catch is fitted into a notched plate on the connecting bar, the assembly is held rigid with the two rubber balls equally withdrawn from the sample tube. As will be seen from the photograph (Fig. 3a) the rubber balls are not centred exactly over the sample tube when the apparatus is set " open," as they are adjusted to fit exactly in the tube ends when the apparatus is closed by the movement of the lever arms through a small angle.

To the short arm of the upper lever is attached a short brass striking knob. When a messenger sliding down the rope strikes this knob the short arm of the upper lever is depressed very slightly, so that the connecting bar can disengage from the lever. To facilitate this disengagement a phosphor-bronze spring is attached to the frame with one end bearing against the connecting bar. When the upper lever is depressed, the pressure of this spring pushes the connecting bar outwards and off the upper lever. The two balls are then drawn firmly into the ends of the copper sampling tube and a watertight seal produced. The disengaged connecting bar swings slowly through an angle of 180° and comes to rest hanging below the apparatus by its hinged union with the lower lever (Fig. 3b).



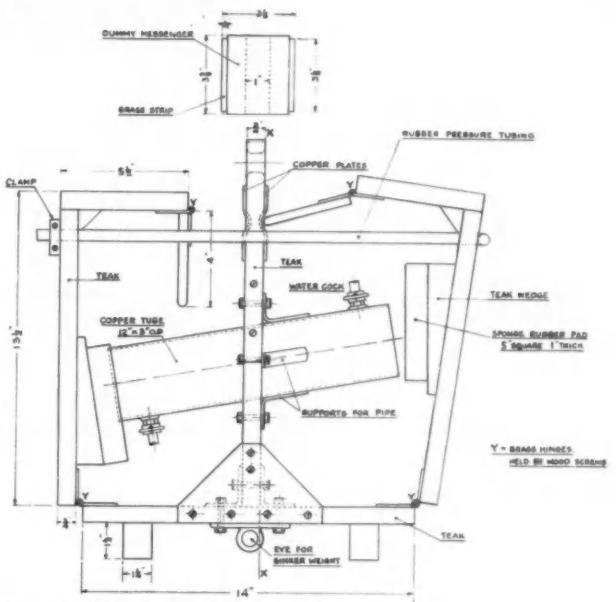


Fig. 2. " Havant " Water Sampler.

As shown in the photographs, it is possible to obtain a simultaneous temperature record by attaching a reversing thermometer to the side of the T-shaped connecting bar. In the model illustrated, there is ample room for this without the thermometer frame becoming foul of the phosphor-bronze spring. When no reversing thermometer is used it is convenient to attach the connecting rod by a short lanyard to the frame so that it only moves through a small angle when disengaged and does not hang free (Fig. 3c).

For the purpose of the photographs, only a light weight has been attached to the apparatus, sufficient to steady it, but in practice a much heavier weight is required for use in a tidal stream. The particular apparatus shown in Fig. 3 weighs 18½ lb. without the sinker.

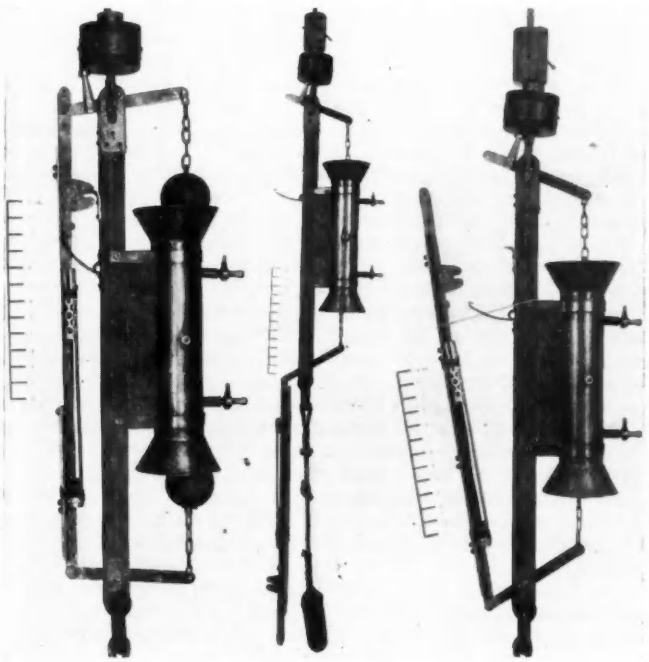


Fig. 3. " Emsworth " Sampler, (a—left) Sampler Open, (b—centre) Sampler Closed, (c—right) Sampler Closed, thermometer not in use.

Messengers.

The apparatus is designed for operation at the end of a rope which is passed through the top of the frame and eye-spliced. The splice necessarily thickens the rope and makes it necessary to have either a messenger with very wide bore, which would slide awkwardly on the rope, or to make use of a loose " dummy messenger " designed to fit over the splice. In the photographs the latter expedient is adopted. The dummy messenger is formed of a cylinder of lignum vitae bound with a strip of brass and with a central hole wide enough to fit over the spliced rope. The dummy messenger is of sufficient diameter to rest on the striking knob, and is lowered with the apparatus.

The operating messenger is a heavy brass cylinder sliding freely on the rope. A segment is cut out of the side of the cylinder to facilitate putting the messenger on the rope. The segment can then be replaced and secured by a split pin. No precision-made spring operated messenger of the usual type used on a wire sounding rope is required.

THE " HAVANT " WATER SAMPLER

The general form of this apparatus is shown in the diagram (Fig. 2) and the photographs (Fig. 4). It consists of the sampling tube, the frame, and the closing mechanism. All wooden parts are made from ¾-in. teak.

Water Sampling in Estuarial Waters—continued

The Frame and Sampler.

The sampler consists of a length of 3-in. diameter copper tube provided with two taps or gas-cocks in the positions indicated. The tap on the upper surface of the tube serves to admit air whilst the sample is being withdrawn through the lower one, which is placed to one side in a position convenient for tapping off the sample.

The fixed frame consists of a base-board about 14-in. long by 6-in. broad, to the centre of which a vertical board 16-in. × 6-in. is rigidly bolted. The upper end of this board is tapered and bored to take the suspending rope as shown in the section in Fig. 2. Through a hole in the centre of the vertical board is passed the sampling tube, which is then clamped in an oblique position. The apparatus is lowered " open," the oblique position of the sampling tube facilitating the flow of water through it.

The Closing Mechanism.

The tube is closed at either end by a pad of 1-in. thick nitrogen-filled sponge-rubber (" Rubazote "). These pads are attached to 13½-in. × 6-in. boards hinged to the ends of the base-board. To ensure that the pads fit evenly all round the rim of the tube in the closed position, they are supported at an angle to the

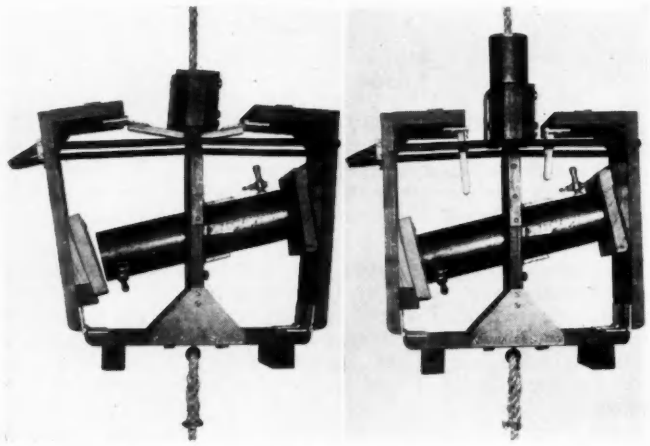


Fig. 4. " Havant " Sampler, (a—left) Open, (b—right) Closed.

hinged boards by wooden wedges. Tension to hold the closing pads in position is applied by a length of rubber tubing or stout elastic passing round the whole apparatus and attached to the free ends of the hinged boards. In the model illustrated the necessary tension is provided by a single suitable length of rubber pressure-tubing, passing through holes in the hinged boards, the ends being secured by metal clamps on the outer side of the left-hand board.

The apparatus is held in the " open " or lowering position (Fig. 4a) by hinged metal falls attached to the top of the hinged sidepieces. The free ends of the falls rest in depressions in the upper end of the centre board of the frame and are held there firmly by the tension of the rubber belt. The depressions are covered by short bent strips of copper to protect the centre board from wear and to ensure that the falls move smoothly out of the depression when struck by the messenger. To ensure that the falls do not foul the collecting tube when they are displaced downwards they must be rather short, and this is achieved in the apparatus illustrated by attaching them not directly to the side pieces but to short cross arms attached to the tops of these latter. Owing to the oblique position of the sample tube the fall on one side of the apparatus must be rather shorter than that on the other.

Operation.

As with the rubber ball sampler, a dummy messenger is required covering the junction of the rope and the top of the centre board of the frame. In this model, the wooden dummy messenger is shaped like a bottomless box and is weighted by brass plates to prevent it floating. The lower end of the dummy messenger rests on the metal falls. When the operating messenger strikes the " box " the free ends of the falls are driven downwards and out of the depressions in the centre board. As soon as this happens the tension of the rubber band pulls in the hinged side-pieces until the sponge-rubber pads press firmly over the ends of the copper tube making a water-tight seal (Fig. 4b).

A sinker of suitable weight is attached to an eye or link bolted into the underside of the bottom board of the apparatus. The weight of the apparatus without sinker, as illustrated, is approximately 25 lb.

PART II—CLOSED-OPEN-CLOSED SAMPLERS

It is sometimes necessary, and it is becoming increasingly so, to investigate the spread (horizontally and vertically) of various effluents of dyes used to reveal water movements, and of various toxic substances discharged into estuaries or other bodies of water.

To do so effectively requires the taking of water samples from below surface which are quite definitely characteristic of the sampling depth alone, and are certifiably free from any admixture from water layers through which the sampler is lowered and raised.

This requires the possession of a sampler which can be sent down closed, can be opened and closed again at the desired depth, and can be brought up firmly closed. With such an apparatus, the collecting vessel could be well sluiced out between the hauls (with distilled water under rigorous conditions), and could be sent down again innocent of any content of the substance whose distribution was under investigation.

Two things are immediately clear: any really simple apparatus will have a depth of use limit owing to considerations of water pressure, and the work will be important enough to require that the depth of sampling is known with some degree of accuracy. A progressive attack upon these particular sampling problems has been made. The first sampler to be made and used (so far as the present writers are concerned) is designated the " Carruthers/Harwell Sub-Surface Water Sampler." This simple apparatus was constructed at the Atomic Energy Research Establishment at Harwell to the suggestions of one of us.

As figured and described the sampler was useful but hardly good enough. Reason exists to suppose that it did not always open at both ends, a likelihood evidenced by the fact that it was usually retrieved only partly full.

Operated hanging freely, the pulling on the snatch line cants the sampler. This by itself does not matter, and could be minimised by using heavy sinkers, but the chief trouble arose from the inability to give a short pause at the open position to ensure a complete fill of the cylinder. In view of the pressure to be overcome when the operating line is pulled, it is not possible to detect and to hold the open position. Moreover, if, as appeared likely, the cylinder does not open at both ends, the cylinder would not be completely emptied of air; a cushion of air under pressure would remain inside if the cylinder opened only at one end.

It was clearly necessary to modify the sampler to ensure both two-end opening and the cant which would make certain the complete removal of air with consequent full filling.

None the less, this sampler has been found of good service to the Port of Bristol Authority in the hands of their Haven Master, Commander Richard Walker, R.N.R., to whom we are indebted for an account of the way in which he has used it to ensure the taking of samples from precisely-known depths. His method will be described later after an account has been given of the first modification of the closed-open-closed sampler just described.

This first improvement is referred to for convenience as the " Tilbury " sampler—a name given in acknowledgment not only of the testing facilities accorded to us by Dr. J. Grindley, leader of the Thames Survey now being carried out by the Water Pollution Research Laboratory from their station at Tilbury, but also in token of a suggestion due to Dr. Grindley which is incorporated in it.

Samplers such as those so far described, which depend for their operation upon the forcing open, against water pressure, of the ends of a closed cylinder by a pivoted bar, obviously have a limit as far as depth of water is concerned. At depths greater than, say, 60-ft., it is considered that they would tend to become unwieldy due to the need to strengthen the moving parts to cope with the

Water Sampling in Estuarial Waters—continued

forces required to operate them under great pressure. The weight of the sinker must also be increased, and the "pull-off" may rise to more than can be applied manually. All this would render them unsuitable for operation from a small boat, or even from a launch unless fitted with a power winch.

Consideration has therefore been given to the design of a sampler which, while retaining the advantages of the closed-open-closed feature, is operated by a heavy messenger, the time interval required for the cylinder to fill being governed by the length of the messenger. In this case, the depth at which the sampler would operate would be limited, within reason, only by the weight and shape of the messenger.

An instrument of this type, known as the "Cricklewood" sampler, is under experiment.

THE "CARRUTHERS/HARWELL" WATER SAMPLER

Description.

This sampler consists of a wooden frame made up of a base carrying a centre piece, a long side and a short side (Fig. 5).

The centre piece, which is secured at the base by brass brackets, carries a hollow brass cylinder, which passes through it at right angles and is rigidly fixed to it.

The long and short sides, which are hinged to the base, bear circular soft rubber pads at the level of the cylinder ends. The two sides are constrained inwards towards the centre piece by two square-section rubber bands, which pass completely round the whole frame and are secured to the sides by wooden clamps.

At the top of the short side, whose width is reduced locally for the purpose, is pivoted the operating bar. This consists of two brass rods, each 1¼-in. longer than the base, one at the front and one at the back of the frame. They are cross-connected by two smaller rods, the one nearer the long side carrying an eye. The ends of the brass rods are rounded and bear against the inner surface of the long side. The operating rod is prevented from moving beyond the limits of the frame by a short horizontal wooden stop at the top of the long side, and by one of the cross-connecting rods bearing on the top of the cylinder.

The cylinder, which is open at both ends, carries a stop-cock near the underside at one end and an air inlet valve near the top at the other. The stop-cock is designed for the fitting, if desired, of a short length of rubber tubing.

The sampler is suspended from a lowering line, which passes through a hole in a horizontal wooden distance piece fixed at the top of the centre piece, and is knotted on the opposite side of the centre piece. The centre piece projects beneath the base to provide a fixing for a line to which a sinker is secured. A light snatch line is made fast to the eye of the operating bar.

The overall dimensions of the sampler are 15-in. × 9-in. × 5-in. and the weight is 5 lb. A pull of 7—8 lb. (in air) on the snatch line is sufficient to operate the sampler. The volume of the cylinder interior is 270 c.c.

Operation.

A sinker of suitable weight is attached to the base of the sampler, and the cylinder stop-cock and air inlet are closed. The operating bar is pushed down to position A, shown dotted in the diagram. In this position the soft rubber pads bear on the ends of the cylinder, which is thus kept watertight.

The sampler is lowered over the side, care being taken to keep the snatch line slack and clear of the lowering line. On reaching the required depth, a slow, steady pull is applied to the snatch line. This causes the operating bar to rise, forcing the two sides of the frame apart. When the operating bar reaches the horizontal, the frame sides are in positions B, shown dotted in the diagram. The rubber pads will by now have moved well away from the ends of the cylinder, which fills with water. As the operating bar continues its upward travel, the two sides of the frame move inwards again, until the bar reaches the stop at position C, shown in full in the diagram. In this position the rubber pads once more bear against the ends of the cylinder, which is thus closed, and the water collected is trapped inside.

The sampler is then raised to the surface, brought on deck and washed in clean water to remove any extraneous matter which may have adhered on the way up. The water sample is drawn off by opening the stop-cock and air inlet.

Tests.

Preliminary tests of the sampler made from a bridge over the Thames at Culham showed that samples of up to 250 c.c. could be collected successfully. During further tests at Sellafield, however, it was found that at the greater depths the effects of currents on the snatch line and pressure on the cylinder ends made it difficult to pull the operating bar sufficiently slowly to allow the cylinder to fill completely, and smaller samples were usually obtained. Although these reduced samples were sufficient for analytical purposes, comparison with standards was rendered more difficult.

THE "TILBURY" WATER SAMPLER

Description of First Model.

The first modification made to the "Carruthers/Harwell" sampler, designed to ensure that both ends of the cylinder opened, was to fit a two-ended operating bar, pivoted at the centre piece,

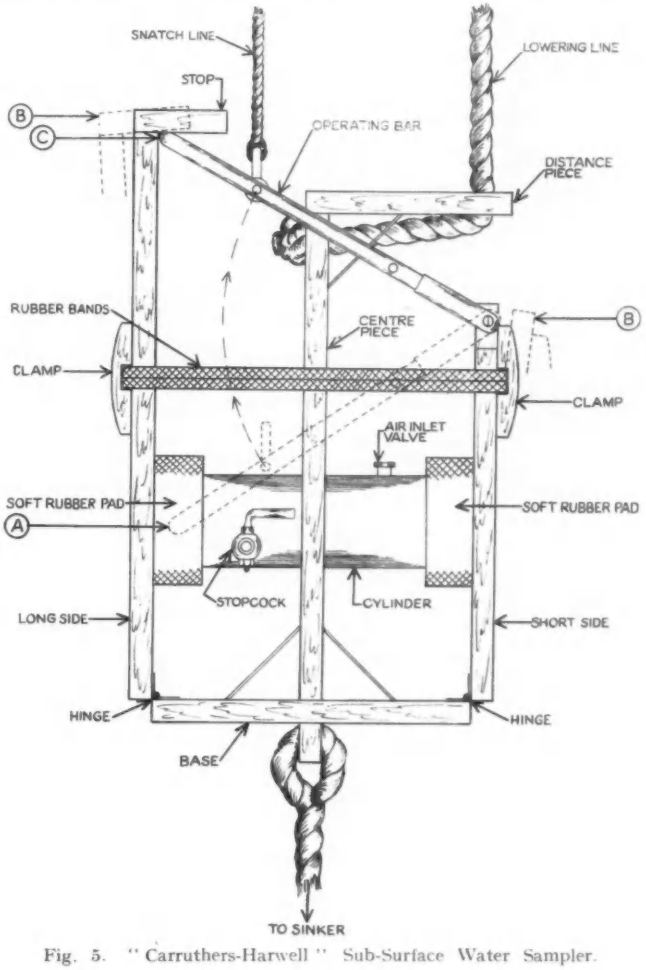


Fig. 5. "Carruthers-Harwell" Sub-Surface Water Sampler.

instead of the single-ended bar pivoted at one side. To compensate for the resulting loss of moment about the pivot, brass rollers were provided, at each end of the bar, to work against the hinged sides, and the point of attachment of the snatch line was transferred to one end of the bar.

The connection for the sinker was moved to the side of the base in an attempt to make certain that the cylinder remained canted during operation and to hasten the ejection of air from it. At the same time an ordinary tinplate funnel, with the stem cut and reconnected at an angle so that the conical portion would be horizontal when the sampler was suspended, was fitted to one side

Water Sampling in Estuarial Waters—continued

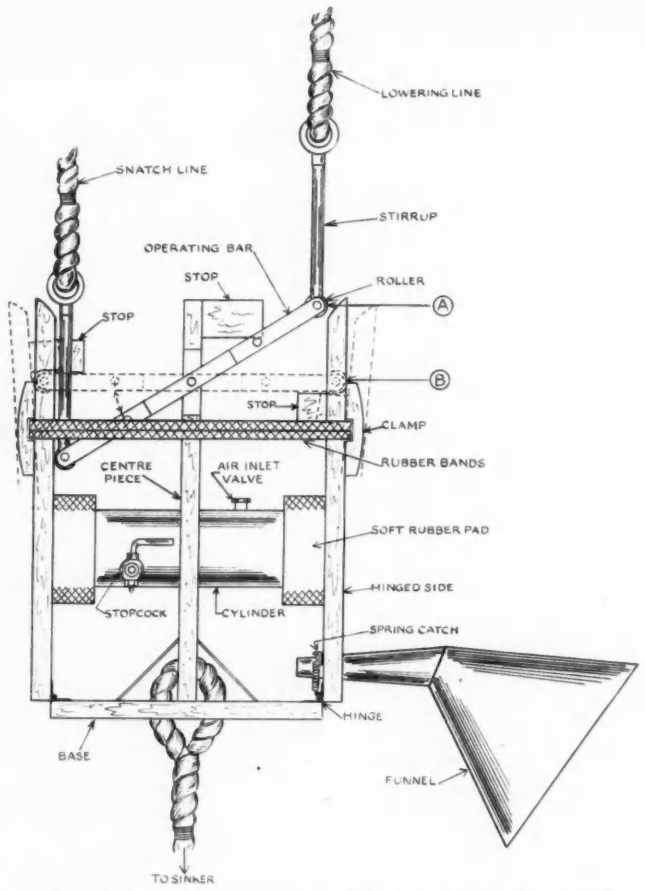


Fig. 6. "Tilbury" Sub-Surface Water Sampler (Second Model).

of the sampler to act as a vane to keep the lines from fouling. A simple spring catch, fitted into a slot at the end of the funnel stem, served to keep the funnel in position and to permit easy removal.

Tests of First Model.

Through the good offices of Dr. Grindley, of the Water Pollution Research Laboratory, the first model was tested in the Thames between Tilbury and Gravesend. It was found that at depths down to about 20-ft. all air escaped from the cylinder and a full sample was obtained. At greater depths, however, the increased pressure on the cylinder ends necessitated such an increased "pull-off" that the operating bar moved too quickly to allow all the air to escape. This defect became progressively worse with depth.

A further difficulty that arose, due to the strong tide and wind conditions obtaining, was that no indication of the actual depth of the sampler was obtainable at the moment of operation.

Description of Second Model.

To overcome the quick-opening defect, use was made of a suggestion put forward by Dr. Grindley during tests of the first model. This consisted of suspending the sampler, when closed, from one end of the operating bar, and providing stops which prevented the bar from moving past the "open" position.

The operation of the second model is therefore as follows: The sampler is sent down closed, with the lowering line attached to the upper end of the operating bar. On reaching the required depth, the snatch line, which as before is made fast to the opposite end of the operating bar, is pulled; this raises the bar to the "horizontal," when it comes up against the stops, and opens the cylinder. After a suitable time interval the weight is re-transferred to the lowering line, which results in the operating bar returning to the closed position.

The second model of the "Tilbury" sub-surface sampler is illustrated in Fig. 6.

While the second model was being designed, a report was received from Commander Walker, who had been using the "Carruthers-Harwell" sampler at Bristol, of a satisfactory method of ensuring operation at known depths. The boat from which observations are being made is first anchored, and a heavy sinker is lowered on to the river-bed on a bight of rope. One end of the bight is secured to the bottom of the sampler, which is then hauled down, by means of the free end of the bight, to the required depth. After operation, the sampler is hauled back on board by its lowering line. A series of observations at known depths can thus be readily made with the sinker in one position (Fig. 7a).

Calculations made during the design stage showed that the required "pull-off" was about 1½ lb. per foot depth + 10 lb. (to overcome the constraint of the rubber bands). At a depth of 60-ft. the pull upon the operating bar would be of the order of 90-lb., and the bar was in consequence strengthened accordingly.

Tests of Second Model.

The second model was tested on the Thames a mile or two below Shellhaven. The tidal stream was running at about three knots, and difficulty was found in using the Bristol method of hauling the sampler down to a sinker at the bottom. With the boat at anchor the sinker available (about 1 cwt.) was swept off the bottom, and the lowering line and snatch line could not be brought to the up and down position to permit depth-taking with any degree of accuracy.

The boat was therefore allowed to drift and the sinker lowered to 60-ft. and kept off the bottom. With this method the lines could be hauled up and down (i.e. vertical) and the sampler hauled down to reasonably accurately known depths. Samples of 250 c.c. were obtained every 10-ft. down to 60-ft. It was quite easy to feel when the sampler had opened and closed.

A check for watertightness, made by lowering the sampler and bringing it up closed, showed that leakage was taking place. This was traced to the pads, which were of very old sponge rubber of loose texture, and to the top of one of the sides taking against a roller before its pad had seated firmly against the cylinder end. The defect was cured by fitting "Rubazote" pads and by cutting away the tops of the sides at an angle, as shown in Fig. 6.

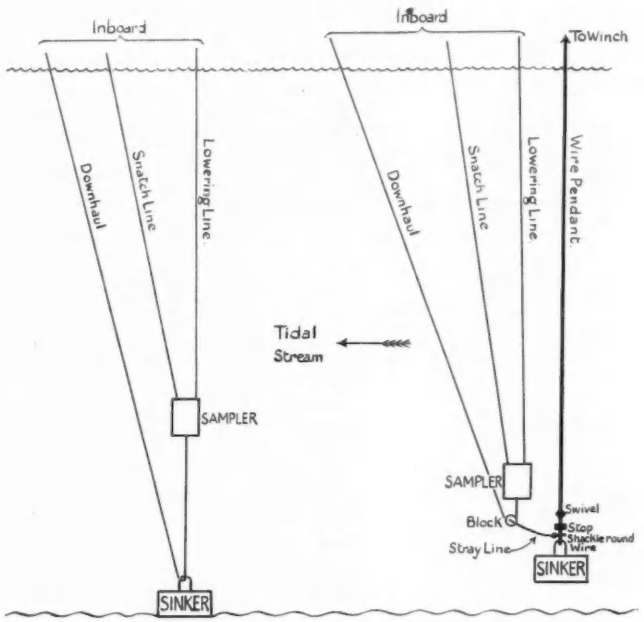


Fig. 7. Bristol Method of operating Sampler.

Water Sampling in Estuarial Waters—continued

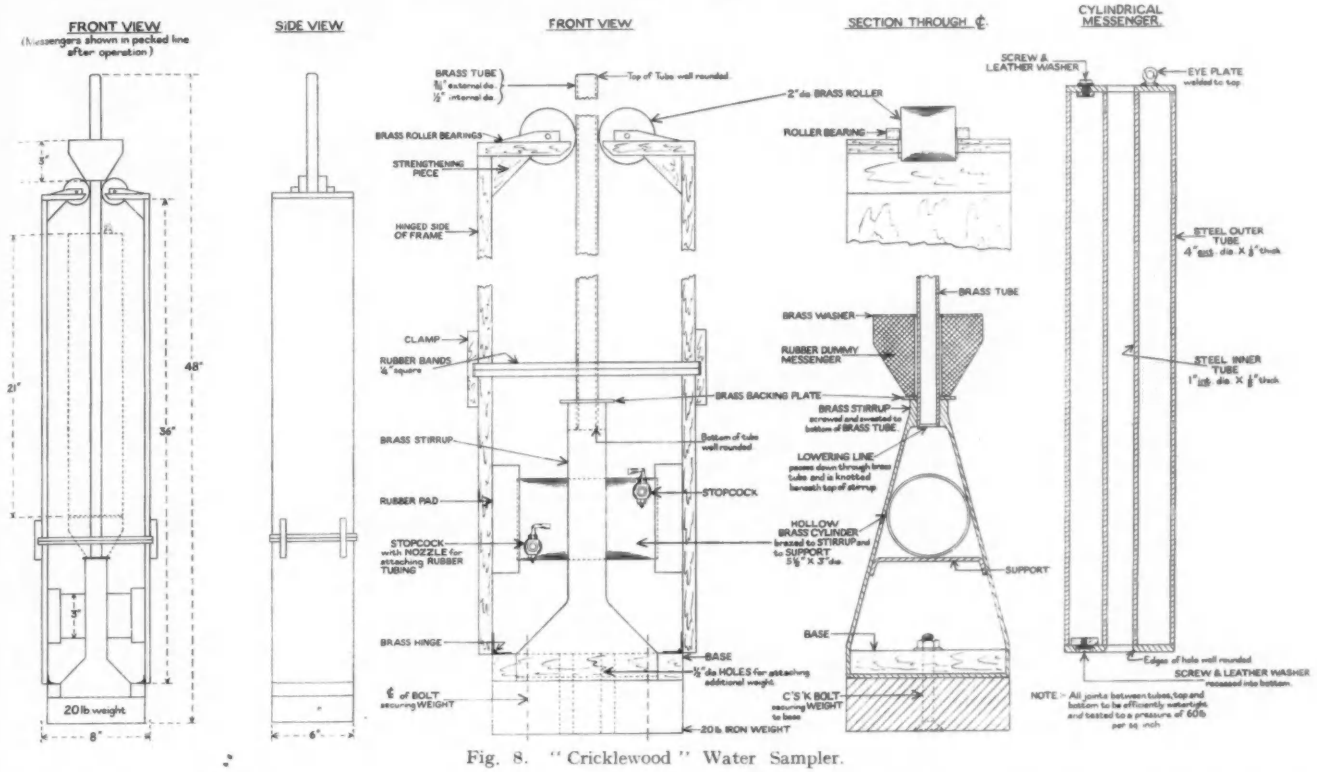


Fig. 8. "Cricklewood" Water Sampler.

Even using the modified Bristol method of operating the sampler, as described above, there was always some danger of the lines fouling. A suggested rig, to overcome this difficulty, is shown in Fig. 7b.

THE "CRICKLEWOOD" WATER SAMPLER

Description.

The essentials of the "Cricklewood" sampler are similar in many respects to the "Carruthers/Harwell" and "Tilbury" types (i.e the action of the hinged sides, constrained by rubber bands, in opening and closing the cylinder is the same) but here the resemblance ends.

The 3-in. diameter cylinder (volume approximately 500 c.c.) is secured to a roughly triangular brass stirrup, which passes right round the wooden base. The base carries a detachable 20 lb. weight, and provision is made for attaching additional weights, or a downhaul to a mooring sinker, by means of holes in the base. The two sides, hinged to the base as before, are 36-in. long, and carry 2-in. diameter brass rollers at their tops.

To the top of the stirrup is screwed and brazed a hollow brass tube, whose internal diameter is about the same as the diameter of the lowering line, which passes through it and is knotted beneath the stirrup. The tube projects some 8-in. above the tops of the hinged sides, and its top is well rounded. A brass backing plate is fitted above the top of the stirrup.

The cylindrical steel messenger which operates the sampler is 21-in. long and 4-in. in diameter; down its centre is a hole of slightly larger diameter than the brass tube. The messenger is hollow, with screwed plugs at either end to allow it to be partially filled with water to increase its negative buoyancy. Unweighted, it has a negative buoyancy of about 3½ lb. A metal eyeplate is provided at the upper end so that the messenger can be lashed to the rail while the sampler is being lowered. A small rubber dummy messenger with a pointed nose is provided to take the blow of the steel messenger.

The "Cricklewood" sampler is illustrated in Fig. 8.

Operation.

The sampler is lowered over the side to the required depth (or pulled down to it by means of the sinker if the Bristol method is used) with the dummy messenger resting on the tops of the rollers. The steel messenger is released and slides down the lowering line. It strikes the dummy messenger, which forces the rollers apart, and thus opens the ends of the cylinder. Once the pressure is removed from the cylinder ends, the hinged sides are only constrained by the rubber bands, and both messengers slide more slowly between the rollers, keeping the cylinder open the while. Finally they come to rest on the backing plate, the dummy messenger acting as a cushion. The rollers move inwards once more and close the cylinder. The sampler is then hauled up and the sample drawn off in the usual manner.

In addition to its positive action and the fact that it allows use at greater depths, this sampler requires only one line (though two if the Bristol method is used) over the side.

For accurate depths taking, and particularly where it is not desirable or practicable to use a sinker as in the Bristol method, a Kelvin tube can be lashed to one of the sides of the sampler. In waters of low salinity, some non-chemical depth indicator, such as the Dobbie-McInnes depthometer, could be attached.

CLEARANCE OF ENTRANCE TO RIVER TYNE

The Admiralty has announced that their salvage organisation has now completed the difficult task of removing the Belgian steamer "Brabo" (3,707 tons gross) from the dredged channel, River Tyne. Following a collision during the war years, she foundered when making for a suitable beaching ground inside the Tyne piers.

During the past three summers, work has gone forward on the removal of the double bottoms. Most of this had sunk beneath the sands, but yet remained above the level of the original dredged channel bed. High pressure hydraulic jets to break up the sand and compacted materials, and air lifts of improved type to convey the materials away, were designed by the Salvage Department. By these means shafts were sunk down through the sands to points below the level of the keel and tunnels driven under the wreck by the divers.

Lifting wires, with breaking strains of 250 tons each, were then taken through these tunnels and placed round the remains of the wreck which was later raised and carried out of the dredged channel by two 1,200 ton Admiralty lifting craft.

A 2,000 Ton Railway Dry Dock in Copenhagen

Conversion of a Wheel and Beating Slipway

For centuries, even before the days of the Hanseatic League, Copenhagen, Denmark, was renowned as a centre of trade, shipping and shipbuilding, its vessels plying the seven seas. During the more recent era, Burmeister & Wain, in Copenhagen, acquired an enviable reputation for excellence in naval architecture and shipbuilding, and is noted for its pioneer work in the development of diesel engines. In 1947, its extensive shipyard consisted of modern shipbuilding ways, fabricating shops, two large floating dry docks, a medium-size basin dry dock and three English-type slipways.

The slipways, of about 1,000 tons capacity, were installed some 70 years ago. The cradles were open framed, three-way structures, supported by truck wheels running on crane-type rails. The track above water level consisted of an elaborate arrangement of brick arches and vaults supporting a series of granite blocks under the rails of each way and the paving between the ways, forming the working floor. This system of arches was supported in turn by brick columns resting on wood piling. The submerged portion of the track was made of yellow pine, three longitudinal members under the rails supported by cross caps and wood piling. Each cradle was hauled by a series of eye-bars, ten feet long, connected to a hydraulic piston with an equivalent stroke. To haul a vessel, the hydraulic piston, in each case, would pull up ten feet, then with the cradle held on a pawl, an eye-bar would be removed, the piston returned to its original position, reconnected to the eye-bars, and the operation repeated. This required 40 men for four to five hours and a nearly equal time and man power for lowering.

Old Slipway showing eye-bar haulage.

The tracks of these old slipways were found to be in remarkably good physical condition, although they showed considerable settlement due to heavy load concentrations under the forefoot, inevitable where the line of keel blocks is parallel to the slope of the ways. However, because of the man-hours involved in operation, consideration was given to the adoption of something more modern and economical and it was decided as a first step to install a railway dry dock of 2,000 tons capacity of the following characteristics, on the site of the middle unit:—

Length over keel blocks	240	ft.
Width over transverse beams	41.7	ft.
Ultimate width over transverse beams	54	ft.
Depth of water over keel blocks at daily water level—forward	7	ft.
aft	14	ft.

New Railway Dry Dock—rollers and hauling chains in foreground.

Normally a railway dry dock of this capacity would have a two-way track for best economy. However, in view of the excellent condition of the old foundations, it was found advantageous to use three ways supported on the existing structure and foundation except for a short entension at the lower end. For the portion above normal water level, the track was constructed of concrete, each way resting on the original granite slabs. The balance of the track was oak, constructed as a unit ashore and sheathed for protection against marine borers. Superimposed on the old track structure, it was carefully adjusted for alignment and gradient, then fastened in place. Special cement mortar was used between the top of the old track and the bottom of the new one of such thicknesses as necessary to provide a uniform gradient.

The cradle, of structural steel, consists of a heavy central longitudinal runner and two side runners, corresponding to the track ways, carrying the principal transverse beams. Because of the existing slipways at either side, it was not possible to make these beams of full length necessary for the docking platforms, but these are to be lengthened and docking platforms erected at some later date when the adjacent slipways will have been removed. The cradle is decked for the full length to provide a convenient working floor. There are 15 bilge blocks on each side sliding along the transverse beams, to be operated eventually by chains and hand winches along the docking platforms, but which in the interim are used as fixed blocks.

The cradle moves on free rollers of alloy cast steel, of the relieved tread type, between flat steel shoe plates on the bottom of the cradle runners and similar rails on the top of the three ways of the track. These rollers are assembled in steel frames with renewable malleable iron bushings for the roller pintles. The cradle is hauled by two open-link chains of heat-treated alloy-cast steel, which, passing around toothed chain wheels (sprockets) on the main shaft of the hauling machine, are connected on an endless system with smaller welded backing chains. The hauling machine consists of a train of steel gears operated by an electric motor of 200 horsepower which will haul a capacity load in 30 minutes.

The hauling machine, hauling chains, rollers, other castings and lumber were shipped from the United States. Messrs. Burmeister & Wain fabricated the steel cradle structure and roller frames.

With this railway dry dock, once a vessel is grounded on the blocks, only two men are required for less than half an hour to have it clear of the water ready for repairs, and a similar period for undocking it an appreciable saving in time and men over the old slipway. Previously two days were required to dry dock, clean, paint and float a vessel—with the new railway dry dock this can be done in one day.

The project, designed by Crandall Dry Dock Engineers, Inc., Cambridge, Massachusetts, U.S.A., was completed and the first vessel dry-docked in February, 1949, and since has been in constant use. Messrs. Poul Lorentzen, A. E. Nellemann and K. E. Gudum-Olsen handled the work for Burmeister & Wain.

Development of Inland Waterways

Suggested Future Policy and Towage Methods

By E. G. JONES

A short time ago I was standing on Waterloo Bridge looking at the Festival of Britain Site designed to show our overseas visitors something of Britain's industrial activities. I thought of the congested streets of the City of London, and of the Thames beneath me at half-flood with very few craft on the move. Instinctively my mind turned to my own industry—our inland waterways—and I began to ponder the prospects of developments in that direction which could play some part in the British transport economy field. I have spent the whole of my working life in the industry, building and operating craft. I have seen improvements that were worthwhile as well as developments that failed to achieve their purpose.

It is true that there are many miles of derelict canals which seem sadly out of place in a highly industrialised community such as ours, yet anyone can see that there is still a remarkable vitality in the industry to-day. Canal trade still goes on, a competitive form of transport holding its own against all the advantages of road-transport with its modern diesel lorries, whilst still largely employing the same age-old methods adopted in the days of our great-grandfathers. It would be true to say that there are times on the River Lee, and the Brentford and Regents Canals, when the undertakings are taxed to capacity, and that any further increase in tonnage, with the subsequent increase in the number of barges required would lead to even further congestion and higher costs.

There have been many articles in The Dock & Harbour Authority and other journals all making useful contributions to this interesting subject, nevertheless it would seem that we are wasting our energy trying, as has been suggested, to form some kind of plan to connect up the four ports (London, Bristol, Liverpool and Hull) with cross-country estuary craft. This idea seems to be looking too far ahead—a long-term plan before ways and means of holding on to the short-distance traffic have been found. Everyone in the industry is aware that there are only two ways of holding and increasing the short-distance traffic; either the carrying capacity of the craft must be increased, or more efficient and economical methods of operating them must be found.

In many suggested plans for improvement there is one argument which appears to be unconvincing, and that is, the urge for uniformity of locks and craft throughout the whole of the canal system. Every carrier is aware that the capacity of the entrance lock from the tidal waters to non-tidal waters influences the cost of tonnage into a canalised system, and a small lock raises the cost of operating canal barges in tidal waters calculated on a tonnage basis. But perhaps the greatest argument against uniformity of locks and craft, apart from its being a most lengthy and expensive business, is that you cannot treat barges as you would railway trucks, pushing them into a siding to be sorted out for their destination days later. They are much too expensive, and wasted days very often mean wasted cargoes. It is not practicable for any carrier to try to arrange his loading programme if he is unable to calculate to any degree of accuracy when his craft will be returning empty.

FOUR NATURAL HIGHWAYS

The physical set-up of our inland waterways system consists of the four main ports on the Thames, Humber, Mersey and Severn, all providing natural highways at a cost of so many pennies per ton. It appears therefore that in order to make the best possible use of these natural highways, it is necessary to trade the estuary craft as far inland as possible. This will provide both a short and a long-term policy for canal improvement. Now this is no new idea, it is exactly how the canals were planned by the early pioneers and the evidence is there to-day for anyone to see; the first tidal locks are in many instances the largest locks. On the Thames to-day we can see a 250-ton estuary barge entering the canalised non-tidal upper reaches to the new Kingston power station.

Now let us take a brief look at the direct route from London to Birmingham on the Grand Union Canal. The connection between canal and tidal water is situated at Brentford where the first mile from the Thames consists of a series of bottle-necks; to clear one would only lead to further congestion at the others. There is only one way, apparently, to get bigger craft into the system, and that is to cut a new entrance on the westerly side of the G.W.R. Docks, linking up with the old canal above the existing toll-lock. It is possible to picture a new cutting reaching up to the Hanwell Locks, roughly 90% of it passing through undeveloped land. Such a scheme would develop Brentford into a very important distributing centre for waterborne trade—a trans-shipment centre from craft of 300-tons capacity into smaller canal barges. Again this is no new idea; a new entrance was thought of many years ago.

NEW WORKING METHODS NEEDED

In considering the second method of improving conditions by increasing the efficiency in the method of working craft—and one incidentally which can be brought about immediately and without any alterations to existing plant—it is well to bear in mind this important fact. Under present conditions, and taking a broad average, a canal barge spends only about one-third of its life usefully as a carrying vessel, and even then a very long period is spent at rest either waiting to be formed up into a "convoy," waiting to be passed through locks, or awaiting its turn for loading or discharging.

Why is there all this delay and waiting? Is it not because the practice still prevails of taking a string of barges at a time through a system which was, and still is suitable only for craft working singly? (Narrow boats, of course, are not referred to as these usually work in pairs.) Everybody in the trade is aware that the normal self-propelled barge is very efficient but only economical if it can be kept on the move, and it is for this reason that we see them mostly working in the bulk oil-carrying trade. But this type of craft suffers a great disadvantage because the propeller is too close to the bottom of the artificial canals when proceeding loaded although they work very well in the canalised river. Therefore at present we have only two alternative methods of mobilising the craft on canals; one is by traction from the tow-path—the canal horse can still be seen working in the London area—the other method is to tow a string of barges by tug.

As soon as a string of, say, four barges and a tug arrive at a lock which can only accommodate the vessels singly, a bottle-neck is caused and these five vessels and six men are at a standstill for over an hour while the craft are passed through. The congestion which occurs when two such strings arrive from opposite directions at the same lock can well be imagined.

This line of thought may provoke the argument that locks should be built large enough to accommodate a tug and three or four barges at the same time. This would not solve the problem of delay, however, as apart from the problem of water supply (which is an engineer's problem) and the enormous expenses which would be incurred in such an undertaking, craft would still be kept waiting to make up convoys, craft would still pile up at loading and discharging points, and the number of barges required to convey a given tonnage from "A" to "B" would still be excessive. The only answer to the immediate problem of carrying an increased tonnage with the existing craft is to speed up the turn-round of barges and to KEEP CRAFT MOVING.

These last three important words form the basis of an idea behind a new invention which was introduced in October, 1948, and which is now patented both here and abroad. Known as the "Bantam" system it consists of a small and inexpensive diesel-engine pushing tug which is rigidly coupled to the bow or stern of any barge (whether fitted with a rudder or not) by a pair of wire cables which are passed round the barge's quarter bollards and hauled tight by hand-winches fitted on either side of the specially-shaped bow of the tug. No modifications are necessary to convert any barge into a self-propelled self-steering unit for the duration of the voyage and only by one man, seated in comfort at a wheel. This system has been operating successfully on the River Thames for two years, and more recently in wet ballast pits throughout the country, where to date seven 21 h.p. units are handling a total of over 800 ballast barges every week. This new idea may be a stepping-stone in canal development.

When this system was reported in the British technical press,

Development of Inland Waterways—continued

following the demonstration trials of the prototype " Bantam I " on the Thames in 1948, a letter from the editor of a French journal was published expressing his congratulations on the success of the demonstration, and stating that he had been urging the pushing of barges in France for some considerable time, but that he had always been told by French barge-owners that the system was not conceivable, owing to the restricted gauge of the French inland waterways. At his request, further information was sent, and subsequently the system was fully reported in his paper. In the opening paragraph the article stated " It does not often happen that we turn to British navigation to find there some progress worthy of being mentioned in the nature of river transport. It is well known that such plays a very small part in the English transport economy, this being especially attributable to the fact that English navigational waterways within that country are, in general, in a fairly neglected state, so that they are being progressively used less and less." Whatever may be the value of the French writer's opinion, one must admit that there is a certain amount of truth in what he has written, although it is not quite true to say that the waterways are becoming less and less used.

OUTLINE OF PROPOSED NEW SYSTEM

Broadly, the suggestion for making more effective use of the existing craft and conditions is this. Where the volume of traffic warrants, a pushing tug should be employed taking barges singly between the locks, thus running a shuttle service. On arrival at the lock, the barge is entered and the tug then disconnects and withdraws, this operation taking approximately one minute. The man on the barge completes the locking-through operation and is picked up by the next unit while the first unit returns with either an empty barge, or a barge returning loaded.

There are, of course, many different circumstances and difficulties which would have to be overcome, but most of them have been gone into and generally speaking they are not insurmountable. For instance, one might suggest that it would be asking too much to expect a barge to be waiting ready for the return journey every time the pushing tug reaches a lock, but this is largely a question of timing and is a problem which should be quite easily solved. After all, what goes up must come down, and in the main, traffic is surprisingly regular. Similarly there is the question of varying distances to travel in different " pounds." Again, this could be overcome either by increasing the power of the pushing tug in that particular reach or by letting her take two barges at a time. We are not concerned, however, with the finer points of the scheme, the main concern is to put up the bare framework of the idea with the plea that an opportunity be given for the system to be tried out in actual practice. Experience so far in working this system on the River Thames has proved beyond all possible doubt that contrary to the beliefs of many experienced people, pushing barges singly through a canalised waterway is more efficient and more economical than towing a string of barges with a high-powered tug, which requires in many instances, a crew of three or four men. On the work in which the proptotype " Bantam " boat was engaged, it was found that with this method the same tonnage was delivered over the same journey with exactly half the number of barges required by the earlier method of towing four at a time, and with exactly half the number of man-hours incurred. In addition, thanks to the security and manœuvrability of the system, the work was carried out in far greater safety, and was not held up by floods which forced the best of the normal tugs to abandon their tasks. There is an added advantage to be gained in as much as the whole of the prime-motive power is not in one hull, while the cost of four 25 h.p. " Bantam " boats compares very favourably with one tug of 100 h.p.

From a canal maintenance point of view, the pushed barge creates far less wash than one which is dragged through the slip-stream of a tug, and furthermore it has been proved, even in open water, that power for power, an increase of 25% in speed by pushing the payload instead of towing has been achieved. In a narrow channel such as the canals where there is less room for displacement to take place, there is every reason to believe that that increase would be improved upon. Another factor on the economy side is that a 21 h.p. diesel-driven tug will operate all day on a fuel bill of little more than four or five shillings, and where a shuttle service by a single tug was in operation between locks, the need for craft to edge into the banks in order to pass each other would be eliminated with a consequent saving on wear and tear on barges' chines and the canal banks. Rudders and tillers, which are a constant source of worry and expense, could be eliminated and future craft could be built double-ended with a resultant saving of at least 10% in building costs and an increased capacity of about 10-tons on the same dimensions and draft as at present.

Judging by the experience gained from two years' working, this system may be an ideal method of operating craft in a canalised system which would lend to a reduction in operating costs without any alteration whatever to locks or craft. It may be suggested that the system cannot be tried out without providing a boat in each pound, that is not correct, it can be tried out by one boat only in any part of our canalised waterways because all that has to be done, is to measure the cost of operating a single barge between two points, that is between two locks, we already know the cost of passing the barge through a lock, and that is the crux of the whole argument.

Harbour Works at Yserfontein, South Africa

Construction of Jetty and Breakwater

A Harbour at Yserfontein has been constructed for Messrs. Atlantic Ocean Industries, Ltd., to provide berths for their fishing vessels. The contract for the works was signed in November, 1948, and comprised a 600-ft. breakwater in random block work, a 250-ft. jetty, the levelling of the site for and construction of a fishmeal and canning factory, boiler house and storehouse with a seafront of 500 feet.

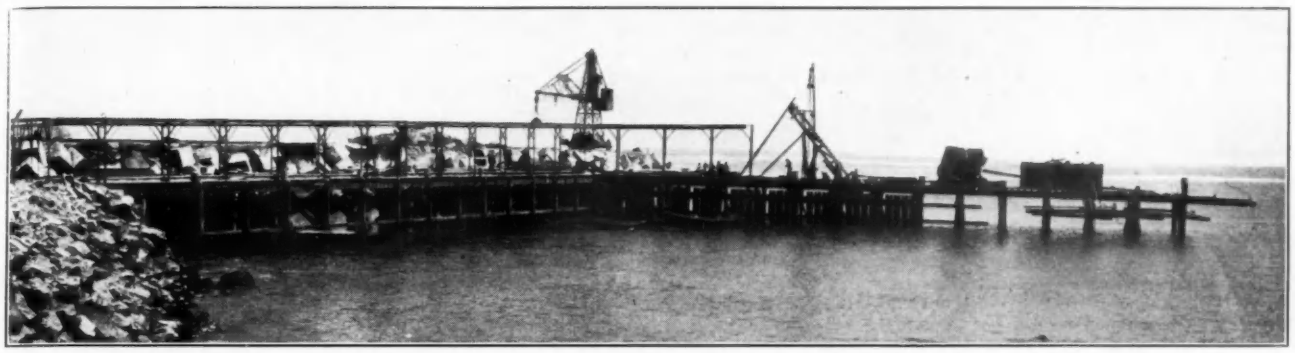
The site is 60 miles overland from Cape Town along the West Coast where a promontory forms a slight bay which offered, under favourable weather conditions, a certain amount of natural protection to a previous jetty, long since fallen into disuse. During most of the year, especially in winter, the swell and the seas from westerly directions from the Atlantic Ocean run in here and the first object was, therefore, the construction of a breakwater.

The owners stipulating the utmost speed of construction, the Consulting Engineer, Brigadier J. F. Craig, decided on a random block mole to a finished level of 14 feet above L.W. and 14 feet wide at the top, the depth of water at 600 feet from the shore being about 30 feet. His design differed from the usual one adopted by the Government for this type of breakwater in-so-far as 10 ton concrete blocks would be accepted instead of the usual 15 ton blocks and instead of a high capping of mass concrete from mean tide level upwards, which would have meant considerable delay owing to frequent high seas, he specified random blocks to near finished level, with only a one foot layer of mass work over the top.

Although many breakwaters have been built on similar exposed coasts, it is felt that the speed of construction achieved on this work might be of some interest. The contractors, Messrs. Murray & Stewart (Pty), Ltd., had undertaken to complete the job before 1950, i.e., within 13½ months of signing the contract, although they knew that most of the summer months, when the seas are not too rough, would have passed before the crane, especially ordered for this work, would be delivered and erected; and before the block-yard could be installed, so that the dumping of the 4,500 blocks would have to start during the incoming winter season, and that consequently a very high output would be necessary as from the spring.

Actually from September, 1949, an average output per week was reached of 162 blocks, cast and dumped, the only double-shift work being in stacking of blocks.

Harbour Works at Yserfontein, South Africa—continued



Work in progress on the timber jetty and breakwater.

The general set-up was as follows:—

On the side of the rocky promotory it proved feasible to level an area of 280 x 60 feet on which two parallel blockyards were constructed, each with two overhead travelling gantries mounted on gumpoles. The blockyards were served by an electric one-cubic yard concrete mixer. The gantries were moved by hand and the blocks were stacked and loaded on trolleys by means of one 10-ton Yale crane to each travelling gantry. As the above mentioned figure shows, a daily production of 30 blocks was eventually kept up. From the blockyard the trolleys with the mature blocks were lowered down a 200-ft. long 10 to 1 sloping ramp to the root of the breakwater where a tractor took over and conveyed them to the crane.

The electric 10-ton hammerhead crane, locally manufactured for this purpose, travelled on a 12-ft. gauge railway track and had a reach of 50 feet. Both the hoisting and the slewing motors were mounted on the turntable 15 feet from the ground so as to be above the spray when the dumping was continued during rough but not quite unworkable weather. The electric current was transferred from the shore through a rubber-protected cable. Every night and whenever the sea came up suddenly the crane was pulled back to safety by an electric winch with a monkey head installed at the root of the breakwater, and the rubber cable was coiled up.

On one occasion this crane dumped 100 blocks in a 12-hour day from which it is clear that given a few calm days the blocks accumulated in the blockyard during rough days could be quickly disposed of. Consequently the main task at hand was to keep the production of blocks cast in the blockyard at a constant high level.

A certain number of smaller blocks were used together with rubble to fill interstices prior to the casting of the mass concrete capping.

As soon as the breakwater was sufficiently advanced to offer protection, that is by the end of September, work on the jetty was started. Again to ensure speed the design was simplified to a construction in timber. Bents consisting of three gumpoles are placed at intervals of 10 feet by means of a mobile crane. The gumpoles are set on the rocky sea bottom in concrete rings filled with tremied concrete. The deck is 20 feet wide at 11 feet above L.W. and the construction is calculated for 10-ton loads. In order to obtain berths with at least 15 feet of water the jetty is L-shaped, the first leg of 150 feet being an approach, the second leg of 200 feet providing the berths. Working as long as daylight permitted 4 to 5 bents were placed per week.

As an additional stiffening the two outside piles of each alternate bent in the second leg are encased in a block of underwater concrete. Throughout the whole length of the jetty a sea-break of sheet piling down to minus 1 is fixed to the piles in order to ensure smoother water in the " seaward inner harbour."

During the coming winter months it will be possible to study the effect of breakwater and sea-break with a view to improvement and extension.

Aerial view of the shore installations and partially completed breakwater and jetty.

Modern Trends in Port Development and Quay Layout

New Handling Methods and Larger Vessels

By THEO T. KNAPPEN
Partner, Knappen, Tippetts Abbett Engineering Co.*

Probably the outstanding trend in port development to-day is the mechanization of cargo handling on the piers. This trend has permitted a very considerable increase in real wages to the stevedoring crews without any total increase in real labour costs of cargo handling. There are, of course, a number of other trends in port development which mostly go along with this process of mechanization. One of these is palletizing of general cargo and the tendency towards the development of containers, both of which fit into the pattern of mechanization. Palletizing has particularly encouraged the development and use of the fork lift truck which to-day is the most generally used mechanical unit in port operations. Palletizing together with the use of stackers has resulted in much higher stacking of cargo in pier areas.

In the last few years there has been a marked and steady increase in the percentage of cargo delivered to piers by over-the-road trucks as well as cargo shipped from the piers by these carriers. In New York about 50 per cent., and in Baltimore about 20 per cent. of the freight is moved by trucks. This means that roadways must be left in the pier area for the free movement of trucks and also areas must be provided for their unloading. The quite general use of trucks for the delivery of cargo to piers in place of direct railroad delivery or lighterage delivery has resulted in greater need for transit storage space, since it is not as easy to co-ordinate truck deliveries as it is railroad deliveries. In case of rail shipment, carload lots may be held in storage yards awaiting the ship, but this is not practical with trucking operations. Many ports that are primarily railroad ports, such as Baltimore, are faced with the necessity of improving their facilities to attract truckers if they are not to lose their share of the growing truck business.

LARGER CARGO VESSELS

There has been another rather marked tendency and that is towards the use of larger ships of the Victory or C-3 class. This means that cargoes of up to 10,000 tons are frequently carried. The cargo ships now in general use from American ports are apt to draw up to 30-ft. when fully loaded and have lengths of about 500-ft. The larger vessels with their greater cargoes mean that more transit storage space is needed for each ship in the general cargo trade.

These factors and trends tend to modify the design concepts for general cargo piers. Until recent years, a finger pier about 150-ft. wide with a two-deck transit shed has been considered the ideal in pier design. This width of pier was dictated by the free length of movement of stevedores in moving cargo in hand trucks to and from the ship's hook. Such a pier would have about 75-ft. available on each side adjacent to the berths. The introduction of mechanical handling equipment, particularly fork lift trucks, has made it practicable and economical to put cargo in transit storage as much as 400-ft. to 500-ft. from the ship's hook. This means that instead of having the transit storage area limited to 75-ft. or 100-ft. in width, it is practical to increase these widths up to 300-ft. or 400-ft. It is also desirable to provide more passageways to permit trucks and cargo handling equipment to circulate freely. As a result, only about one-third of the gross pier area can be used for actual stacking of cargo. So we find that the tendency to-day is to provide transit storage sheds 400-ft. to 500-ft. long and 200-ft. to 300-ft. or more in width. Such sheds provide enough transit storage to permit a fairly continuous utilization of the berth and make it possible to handle about 300,000 tons per year of general cargo through each berth.

Because of limitations on transit storage in the past, it frequently has been necessary for a vessel to discharge its cargo at one berth and pick up its cargo at another. The use of mechanical equipment and increasing the areas of transit storage will tend to eliminate this practice. The use of second floor storage for transit storage purposes is being reduced or eliminated. Unless long ramps with flat gradients are provided, it is difficult to get modern trucks to the second floor of pier sheds. The elevators which currently are in use are in most cases too small for large trucks. Chutes, of course, are used for some types of cargo but their use is not particularly satisfactory and is certainly limited.

CHANGING PIER DESIGN

The modern trend in pier design, therefore, appears to be towards a berth about 600-ft. long with a transit shed adjacent to the berth about 400-ft. to 500-ft. long and 250-ft. or more in depth. Between the face of the transit shed and the face of the pier an apron 40-ft. to 50-ft. in width is usually provided and it is desirable to have at least two tracks on this apron and if there are adjacent berths served from the railroad tracks, it is an advantage to have a third track for serving the other berths. In addition, it is desirable to have track facilities provided on the opposite side of the shed so that cars may be unloaded at floor level. It is also desirable to make provision for unloading trucks at floor level as well as having truck roadways within the transit shed. The clear headway should be about 20-ft. in height and the floor should be designed for load concentrations of 750 pounds per square foot or more.

This modern berth will permit two or three times as much cargo to be handled at one berth as was possible before the days of mechanization. Generally this tends to favour the construction of marginal wharves. Finger piers, of course, can be readily adapted to this design by making the piers wider and also making the slips wider, since ships are wider and larger than they were formerly.

In locations where lighterage is an important factor, such as New York, the finger pier is still desirable. In this case, the width of the finger pier should be 250-ft. to 300-ft. with provision for berthing ships on one side and handling lighters on the opposite side. In the case of finger piers where lighterage is not a factor, the piers may be planned to be 500-ft. or more in width with depressed railroad tracks in the centre of the finger pier, in addition to the tracks on the aprons.

LARGER BULK CARRIERS

While, as already stated, there has been a marked tendency for general cargo ships to increase in size, there has been an even greater tendency for bulk carriers to increase their tonnage very greatly. At the close of the recent World War, the T-2 Tanker, of about 16,000 tons dead weight, had fairly well replaced the pre-war tanker. It was thought at that time that the T-2 Tanker would meet the needs of the petroleum industry for a long time to come. However, in order to meet the increasing labour costs, it has been found desirable to have larger tankers, since the operating crew for a large tanker is about the same as for a smaller vessel. As a result, we have to-day a large number of tankers between 25 and 30 thousand tons dead weight in operation or under construction, and in addition a tendency toward expanding tanker sizes to at least 40,000 tons is now strongly indicated.

IMPORTS OF IRON ORE

The depletion of the iron-ore reserve in the Great Lakes area and in other sections of the United States has led to an extensive search for sources of iron-ore outside the country. Many of these sources are now being developed and it seems more than likely that within a very few years 50,000,000 tons or more of iron-ore a year will be moving into the East Coast and Gulf ports of the United States. The tendency with these ore carriers, as with the tankers, is to make them as large as harbour conditions will permit.

The combination of the large tankers and ore carriers is forcing another review of harbour and channel dimensions. With these bulk carriers being built or planned with lengths up to 700-ft. or more, beams of 100-ft. and drafts of 34-ft. and 35-ft., it becomes necessary to widen, deepen, and straighten the entrance channels to many of our ports and to provide greater depths and turning areas in the harbours so that we have another trend, which is towards developing harbour entrance depths of 38-ft. or more and widths of 500-ft. to 600-ft. on long approach channels and greater widths in the case of shorter channels or extremely busy ports, such as New York, Philadelphia, and Baltimore.

*Excerpts from an address on Port Development delivered to a panel meeting of the American Merchant Marine Conference on 27th September, 1950.